DOE/TIC-3378

Oil Shales

Selected Bibliography of DOE Sponsored Research

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DOE/TIC-3378
Distribution Category UC-91

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January 1980

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ABSTRACT

Four hundred thirty-six citations of reports, journal articles, patents, conference papers, and monographs resulting from Department of Energy sponsored research on oil shales are presented. These citations and approximately 8000 additional citations are a part of the Department of Energy's Energy Information Data Base.

The citations are arranged by subject category. Within the categories references to reports are listed in alphanumeric order by report number. Other citations follow in inverse chronological order. Five indexes are provided: Corporate, Author, Subject, Contract Number, and Report Number.

INTRODUCTION

The economic and environmentally acceptable utilization of the nation's reserves of oil shales represents a challenging contribution to a solution of the national energy dilemma.

This publication presents 436 citations of reports, journal articles, patents, conference papers, and monographs resulting from Department of Energy sponsored research on oil shales. These citations and approximately 8000 additional citations have been cataloged, indexed, and stored in machine-readable form by the DOE Technical Information Center. These citations and those being added on a continuing basis can be recalled and searched using the on-line computer retrieval system DOE/RECON.

Citations of current publications resulting from DOE-sponsored work are announced semimonthly in *Energy Research Abstracts.* Current publications from any source are announced monthly in *Fossil Energy Update.* A bibliography, Oil Shales and Tar Sands (TID-3367), containing 5049 citations was published by the Technical Information Center in December 1977.

The citations in this publication are arranged by subject categories as shown by the table of contents. Within a given category the arrangement is alphanumeric by report number. Citations of unnumbered documents are arranged in inverse chronological order after the reports.

Five indexes are provided: Corporate, Author, Subject, Contract Number, and Report Number.

CONTENTS

GENERAL

1 (CONF-7810176--) COMPOSITION OF TRANSPORTATION SYNFUELS: R and D NEEDS, STRATEGIES AND ACTIONS. (Department of Energy, Washington, DC (USA). Office of Conservation and Solar Applications). Jun 1979. 372p. Dep. NTIS, PC A16/MF A01.

From Conference on composition of transportation synfuels: R and D needs, strategies and actions; San Antonio, TX, USA (11 Oct 1978).

This conference was hosted by Southwest Research Institute with the support of the United States Department of Energy. Persons in attendance were key members of the technical community who are actively involved in the development and utilization of nonpetroleum domestic resources for transportation fuels. Generally, attendees represented the federal, military, industrial, and academic sectors of the domestic effort to develop synthetic fuels. The basic conference objective was to gather and organize facts and opinions which would enable the Department of Energy's Transportation Energy Conservation Division to (a) identify adjustments that may be needed in their Alternative Fuels Utilization Program strategies, and (b) define specific R and D project work on finished formulations of synthetic fuels which may have economic or environmental impact upon the domestic transportation scene. Twenty-two individual abstracts were prepared, all of which will appear in both Energy Research Abstracts (ERA) and Energy Abstracts for Policy Analysis (EAPA).

2 (DOE/ET--0060(78)) FOSSIL ENERGY PROGRAM REPORT, 1 OCTOBER 1976--30 SEPTEMBER 1977. (Department of Energy, Washington, DC (USA). Office of Fossil Energy). Aug 1978. 620p. Dep. NTIS, PC A99/MF A01.

This report is an integral part of the documentation system of the Fossil Energy Program of the Department of Energy. It contains descriptions of each contract and project, arranged in conformance with planning and budgetary documents. The results of contracts are reported at various intervals, depending on the type of contract, but at least annually. These reports are not listed individually in the ''Publications'' sections but are available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161. The Department of Energy also publishes several abstract journals: Fossil Energy Update, Energy Research Abstracts, and Energy Abstracts for Policy Analysis.

3 (DOE/TIC--10032) OIL SHALE: REPORT ON A FOCUS GROUP DISCUSSION. Christophersen, G.R. (Mathematica Policy Research, Princeton, NJ (USA)). 10 Nov 1978. Contract EV-78-C-01-6388. 47p. Dep. NTIS, PC A03/MF A01.

The panel discussion focused on four types of barriers to oil shale commercialization including technological, economic, institutional, and environmental. The discussants agreed that both the size and potential demand for syncrude are massive. It was agreed that if this nation is to develop a domestic industry which is to produce liquid hydrocarbons as an energy source, the the commercialization of the oil shale industry is important. Oil shale is viewed as the most economical option for domestic syncrude. Industry representatives share a strong optimism that an environmentally acceptable technology can be developed that will be economically attractive to industry. The environmentalists are concerned that as of yet no such environmentally acceptable technology has been developed.

4 (DOE/TIC--10142) LARAMIE ENERGY TECHNOLOGY CENTER ANNUAL REPORT 1978. Fumich, G. Jr. (Department of Energy, Laramie, WY (USA). Laramie Energy Research Center). 23 Aug 1978. 63p. Dep. NTIS, PC A04/MF A01.

Laramie Energy Technology Center's research efforts in the areas of oil shale, tar sand, and coal are discussed. Various activities in the Office of Research and Development are reported.

5 (FE--2343-6(Vol.5)) REVIEW AND ANALYSIS OF OIL SHALE TECHNOLOGIES. VOLUME 5. APPENDIXES AND BIBLIOGRAPHY. Jee, C.K.; White, J.D.; Bhatia, S.K.; Nicholson, D. (Booz-Allen Applied Research, Inc., Bethesda, MD (USA)). Aug 1977. Contract EX-76-C-01-2343. 95p. Dep. NTIS, PC A05/MF A01.

Seven appendices are included on: oil shale technology activities, ERDA oil shale program, method of assaying oil shale by a modified Fischer retort, environmental standards and regulations, supplemental information on various true in-situ processing steps, evaluation of in-situ oil shale experments by hot-film flow logging, and discounted cash flow rate of return method. The bibliography contains 133 references. (DLC)

6 (LBL--9857) OIL SHALE RESEARCH: CHAPTER FROM ENERGY AND ENVIRONMENT DIVISION ANNUAL REPORT, 1978. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). Aug 1979. Contract W-7405-ENG-48. 35p. Dep. NTIS, PC A03/MF A01.

The Oil Shale Program at LBL is concerned with the environmental aspects of oil shale production. Information on the chemical composition of oil shale and its byproducts is being developed. This report contains 13 brief papers on various subprojects. Separate abstracts were prepared for eleven of these papers; the remaining two was previously abstracted. (DLC)

7 (METC/SP--78/6(Vol.1)) SECOND EASTERN GAS SHALES SYMPOSIUM: PREPRINTS. (Department of Energy, Morgantown, WV (USA). Morgantown Energy Technology Center). Oct 1978. 461p. (CONF-781010--). Dep. NTIS, PC A20/MF A01.

From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).

Papers and abstracts of papers presented at the conference and included in Volume I are concerned with several aspects of Eastern gas shales. A separate abstract was prepared for each paper. (JRD)

8 (METC/SP--79/6) PROCEEDINGS: THIRD EASTERN GAS SHALES SYMPOSIUM. Barlow, H. (ed.). (Department of Energy, Morgantown, WV (USA). Morgantown Energy Technology Center). 1979. 548p. (CONF-791003--). Dep. NTIS, PC A23/MF A01.

From 3. Eastern gas shales symposium; Morgantown, WV, USA (1 Oct 1979).

Forty-two papers are presented under the following session headings: general, resource characterization, extraction technology, and technology testing. Separate abstracts were prepared for 32 of the papers. (DLC)

9 (R--2293-DOE) CONSTRAINTS ON THE COMMERCIALIZATION OF OIL SHALE. Merrow, E.W. (RAND Corp., Santa Monica, CA (USA)). Sep 1978. Contract EX-76-C-01-2337. 142p. Dep. NTIS, PC A07/MF A01.

The problems and prospects for the commercialization of oil shale from surface retorting are examined. Commercialization refers to the process of private sector adoption of a technology for general use after most of the technological uncertainties have been resolved. Three categories of constraints and uncertainties can be identified: technical constraints relating to the performance characteristics of the technology; economic constraints on the ability of the technology to yield an acceptable rate of return to investors; and institutional constraints that arise from the organizational and political context in which commercialization takes place. Because surface retorting involves relatively well understood technologies, this study deals almost exclusively with economic and institutional constraints. At the present time, a government commercialization effort for oil shale surface retorting would not be likely to result in a viable industry in this century. Alternative oil shale technologies such as modified in situ processes offer prospects of lower shale oil costs, but are less well developed. Data on modified in situ processes are not abundant enough as yet to permit serious estimates of commercial-scale costs. Consequently, government decisions regarding the commercialization of modified in situ technologies should await the completion of further technical tests and an independent definitive plant design.

10 (UCRL--50016-78-2) MECHANICAL ENGINEERING DEPARTMENT QUARTERLY REVIEW, APRIL--JUNE 1978. Stone, R.G.; Bathgate, M.E. (eds.). (California Univ., Livermore (USA). Lawrence Livermore Lab.). 30 Jun 1978. Contract W-7405-ENG-48. 49p. Dep. NTIS, PC A03/MF A01.

The review is presented in sections on x-ray spectrograph development, sampling of gases in a post shot cavity, oil shale retort heat losses, development of an automated thermocouple, seismic engineering, testing fuel rod casks, and nuclear materials control. A separate abstract was prepared for each section. (JRD)

11 ERDA PROGRAM FOR STIMULATING RESEARCH AND DEVELOPMENT REQUIREMENTS OF FEDERAL ENERGY POLICY. White, P.C. (Dept. of Energy, Washington, DC). Am. Chem. Soc., Div. Pet. Chem., Prepr.; 23: No. 1, 371-378(Feb 1978). (CONF-770814--P2; CONF-780305--P2).

From American Chemical Society meeting; Chicago, IL, USA (29 Aug 1977).

Discussions are presented concerning ERDA interactions with industry and other agencies in the development of energy conservation plans, solar energy, oil shale, and coal. (JRD)

12 TENTH OIL SHALE SYMPOSIUM PROCEEDINGS. Reubens, J.B. (ed.). Golden, CO; Colorado School of Mines (1977). 260p. (CONF-770419--). $7.50.

From 10. oil shale symposium; Golden, CO. USA (21 Apr 1977).

Twenty-two papers are included, covering such topics as in-situ retorting, prospects of oil shale technology, properties of oil shales and shale oil, mining, disposal of spent shales, partitioning of elements during retorting, and use of nahcolite byproduct. Separate abstracts were prepared for 19 of the papers; the remaining three were previously abstracted. (DLC)

RESERVES AND EXPLORATION

13 (CONF-790739--2) CASE STUDY OF AN APPLICATION OF COMPUTER MAPPING IN OIL-SHALE RESOURCE MAPPING. Davis, F.G.F. Jr.; Smith, J.W. (Department of Energy, Laramie, WY (USA). Laramie Energy Technology Center). 1979. 20p. Dep. NTIS, PC A02/MF A01.

From Harvard computer graphics week '79; Cambridge, MA, USA (15 Jul 1979).

The Laramie Energy Technology Center, U.S. Department of Energy, is responsible for evaluating the resources of potential oil and the deposit characteristics of oil shales of the Green River Formation in Colorado, Utah, and Wyoming. While the total oil shale resource represents perhaps 2 trillion barrels of oil, only parts of this total are suitable for any particular development process. To evaluate the resource according to deposit characteristics, a computer system for making resource calculations and geological maps has been established. The system generates resource tables where the calculations have been performed over user-defined geological intervals. The system also has the capability of making area calculations and generating resource maps of geological quality. The graphics package that generates the maps uses corehole assay data and digitized map data. The generated maps may include the following features: selected drainages, towns, political boundaries, township and section surveys, and corehole locations. The maps are then generated according to user-defined scales.

14 (DOE/RA--0011) OFFICE OF NAVAL PETROLEUM AND OIL SHALE RESERVE. ANNUAL REPORT OF

OPERATIONS, OCTOBER 1, 1978. (Department of Energy, Washington, DC (USA). Div. of Oil, Gas, Shale and In Situ Technology). Dec 1978. 50p. Dep. NTIS, PC A03/MF A01.

Total production for FY 1978 from Elk Hills (including both the Government's and Chevron's share of production) averaged 119,138 barrels of oil per day (BOPD). The Government's share of this production was approximately 100,000 BOPD. During this period, the Government's share of production was sold at two crude oil sales. There were 11 rigs operating at Elk Hills during FY 1978. At year end, two rigs were active in the development of the Shallow Oil zone, six in the Stevens Zone, and one in the Carneros Zone. Earlier in the year, two additional rigs were utilized for drilling deep exploratory test wells. No new productive horizons were discovered. Work on the Government pipeline, proposed to tie in to the SOHIO pipeline system, has been temporarily suspended due to the uncertainties involved in the SOHIO permitting process as well as a revision in the estimates of peak production capacity from Elk Hills. Most of the Government-owned land at NPR-2 has been leased out to private companies for oil and gas purposes since the early 1920's. Therefore, the Department of Energy's role at NPR-2 is generally limited to overall surveillance as well as production and fiscal accounting. During FY 1978, production at Teapot Dome averaged 1,957 BOPD. All sales during FY 1978, which generated revenues totalling 11,014,212, were to one purchaser, Marathon Oil Company. Expenditures totalled 24,354,434. During FY 1978, expenditures for the Naval Oil Shale Reserves totalled 985,000. Activities during this period included continuation of a three-year surface hydrology study, completion of a seven-well corehole program initiated in FY 1977, and the implementation of another three-well corehole program.

15 (FE--8214-T2) COORDINATION OF STUDY OF THE DEVONIAN BLACK SHALE IN THE ILLINOIS BASIN (ILLINOIS, INDIANA, AND WESTERN KENTUCKY). QUARTERLY PROGRESS REPORT, 1 FEBRUARY--31 MAY 1979. Lineback, J.A. (Illinois State Geological Survey, Urbana (USA)). 1 Jun 1979. Contract EW-78-S-21-8214. 29p. Dep. NTIS, PC A03/MF A01.

Purpose is to develop a basin-wide data base for the Devonian black shale in the Illinois Basin. A preliminary assessment is given of the natural gas potential of the New Albany Shale Group in Illinois. (DLC)

16 (IDO--1683-1(Vol.1)) DAWSONITE AND NAHCOLITE SURVEY. VOLUME 1. RESERVES, TECHNOLOGY, ECONOMICS, AND MARKET ASSESSMENT. Farris, C.B.; Mains, C.J. (Colorado School of Mines, Golden (USA). Research Inst.). Apr 1978. Contract EC-77-S-07-1683. 169p. Dep. NTIS, PC A08/MF A01.

A survey report is presented for dawsonite and nahcolite, based on a bibliography and supplementary information obtained from researchers and mineral experts in the US. This report discusses resources, technology, economics, and market assessment from 1978 to 2000. It is estimated that in the Piceance Creek Basin of northwestern Colorado, there are approximately 27 billion tons of dawsonite and 30 billion tons of nahcolite, codeposited with portions of a vast oil shale deposit. All areas where the saline minerals and oil shale have been codeposited are controlled by the Federal government, with three exceptions. It is currently believed that all other oil shale properties lack recoverable quantities of dawsonite and/or nahcolite. Dawsonite and its derivatives can be used in the alumina, aluminum, catalyst, plastics, and water-treatment industries. Only the alumina and aluminium are large enough to absorb potential production by 2000. Nahcolite and its derivatives can be used in the flue gas scrubbing, glass, soda ash, and potentially dawsonite-recovery industries. Only flue gas scrubbing is likely to be a sufficiently large outlet to absorb potential nahcolite production by 2000.

17 (IDO--1683-1(Vol.2)) DAWSONITE AND NAHCOLITE SURVEY. VOLUME 2. DAWSONITE AND NAHCOLITE BIBLIOGRAPHY WITH ABSTRACTS. Farris, C.B.; Leland, E.H. (Colorado School of Mines, Golden (USA). Research Inst.). Apr 1978. Contract EC-77-S-07-1683. 112p. Dep. NTIS, PC A06/MF A01.

The Dawsonite and Nahcolite Survey included a world-wide literature search. This volume comprises a bibliography, with abstracts included for each citation, representing the results of that search. The author's abstract was used directly if it was included as part of a paper. In many cases, however, these abstracts were too general for the purposes of this study and the author's abstract was expanded. In some cases, the author's abstract was edited to highlight dawsonite and nahcolite aspects. Foreign-language papers were translated only sufficiently to determine their relevance to the Piceance Creek mineral depsits. Generally, these papers reported on foreign deposits and were of limited value. Abstracts are categorized into the following subjects: general, geology and mineralogy, reserves and exploration, mining and processing, properties and their determination, environmental, uses, and competing alumina raw materials and processes.

18 (MERC/SP--77/5, pp 111-126) SUBSURFACE STRATIGRAPHY AND EXTENT OF THE UPPER DEVONIAN DUNKIRK AND RHINESTREET BLACK SHALES IN NEW YORK. Van Tyne, A.M.; Peterson, J.C.; Rickard, L.V.; Kamakaris, D.G. (New York State Museum, Alfred). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

Gamma Ray log correlations of the Dunkirk and Rhinestreet shales were made for 142 wells in western New York. The total Dunkirk section, from West to East, ranges in thickness from 40 feet at the Lake Erie shoreline outcrop to more than 80 feet in Allegany County. The massive black shale portion of the Dunkirk varies from 50 feet thick in Chautauqua County to less than 25 feet in Cattaraugus County. The structure on base Dunkirk indicates a southwestward dipping surface with southwestward trending anticlinal features in Chautauqua and Cattaraugus Counties. The deeper total Rhinestreet, from West to East, ranges from 113 feet at Lake Erie to 1,450 feet in Steuben County. The massive black shale zone of the Rhinestreet varies from 113 feet in Chautauqua County to less than 5 feet in Allegany County. The structure on base Rhinestreet indicates a northeast-southwest trending basinal area with the same anticlinal features seen in the Dunkirk structure. 12 figures.

19 (MERC/SP--77/5, pp 127-144) STRATIGRAPHY AND GAS OCCURRENCE IN THE DEVONIAN ORGANIC RICH SHALES OF PENNSYLVANIA. Piotrowski, R.G.; Krajewski, S.A.; Heyman, L. (Pennsylvania Geological Survey, Pittsburgh). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

Devonian shale gas was produced from shallow

low pressure wells along Lake Erie in northwestern Pennsylvania between 1821 and 1880. Unfortunately, little information on these wells is available. Current production from the Devonian shales in Pennsylvania is limited to two wells, the Welch Foods, Inc. No. 3 well in Erie County and the Metropolitan Brick No. 1 well in Beaver County. Using these wells as a starting point, a network of nine stratigraphic cross-sections is in preparation. The sections provide a stratigraphic framework for the rocks between the Mississippian--Devonian boundary and the Onondaga limestone, Middle Devonina. Special emphasis is given to the highly radioactive organic rich shales in the lower part of this stratigraphic sequence. Three major radioactive shale units are defined: the Marcellus, the Rhinestreet, and the Dunkirk. Preliminary mapping of two of these major radioactive shales, Rhinestreet and Dunkirk, has been completed. These units were mapped since they are the primary producing intervals in the recent shale gas wells in Pennsylvania. The maps indicate excellent exploration potential in northwest Pennsylvania. The Rhinestreet is the more extensive and thicker of the two. It reaches a maximum thickness of approximately 200 feet and extends over most of northwest Pennsylvania. The area of maximum Rhinestreet thickness in eastern Erie and Crawford Counties looks very promising. The Dunkrik is prospective in the extreme northwest portion of the state, primarily in Erie County. 13 figures.

20 (MERC/SP--77/5, pp 145-165) WIRELINE LOGS AND SAMPLE STUDIES IN STRATIGRAPHY AND GAS OCCURENCE OF THE DEVONIAN SHALES ALONG THE SOUTHERN TIE SECTION IN EASTERN KENTUCKY AND VICINITY. Wilson, E.N.; Zafar, J.S. (Univ. of Kentucky, Lexington). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

A stratigraphic cross-section (the Southern Tie section) was constructed from Ross County, southeastern Ohio, through northeastern Kentucky and West Virginia to Scott and nearby Counties in southwest Virginia, using wireline logs (principally the Gamma Ray and Density logs) and sample studies of key wells along the section. Stratigraphic correlation by wireline logs, although the section crosses from the craton in Ohio to the deep part of the Valley-and-Ridge, is straightforward, identifying an alternation of radioactive and relatively non-radioactive shale units (some not present at the base in the northwest) across the whole section. In the southwest, there are more units at the base; and the upper radioactive units have been replaced by a different lithology. But wireline log characteristics are not entirely consistent with lithology as apparent in samples. Radioactivity is usually proportional to organic content or dark color; but some shales and metabentonites have unusual radioactivity, and some black shales (especially those exhibiting moderate rather than low density) are only slightly radioactive. Drillers' shows of gas (indicative of the vertical position of reservoirs) are commonly but not exclusively near the top of radioactive units (the ''Berea'' production of Pike County, Kentucky, being a significant exception). Very low density shales may be related to fractured or sloughing zones, possibly reservoir zones. 9 figures.

21 (MERC/SP--77/5, pp 678-690) USE OF THE SCINTILLOMETER AND GAMMA-RAY LOGS FOR CORRELATION FROM SUBSURFACE TO THE SURFACE IN BLACK SHALE. Ettensohn, F.R. (Univ. of Kentucky, Lexington); Fulton, L.P.; Kepferle, R.C. Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

Stratigraphic studies of the Devonian and Mississippian Ohio, Sunbury, New Albany, and Chattanooga Shales (consisting primarily of black, organic-rich shale) in the eastern portions of Ohio, Kentucky and Tennessee indicate that radioactive units evident on subsurface gamma-ray logs from oil and gas wells penetrating these formations can be distinguished in outcrops and in cores by using a scintillometer. Measurements of gamma radiation made with a portable scintillometer at close vertical intervals along the surface of a black-shale exposure or core are found to produce radioactivity profiles that closely resemble gamma-ray curves from the same formation in the subsurface. Because the units of the scintillometer profiles and gamma-ray curves are not identical (counts/second vs API units), the curves are not comparable on a quantitative basis, although their patterns are qualitatively similar enough to allow good correlation. Except for thin green-shale beds distributed throughout the black shale, exposures of the Ohio, New Albany, and Chattanooga Shales are lithologically homogeneous. Use of this technique has shown, however, that these black-shale formations contain seven major radioactive units, which can now be correlated with named surface and subsurface units. With a scintillometer, the presence or absence and thickness of these units can be determined in otherwise homogeneous-appearing exposures of the black shale or in cores from wells lacking gamma-ray logs. Use of this scintillometer technique together with gamma-ray logs has proved useful in defining an internal basin-wide stratigraphy for the Devonian and Mississippian black shales. 11 figures.

22 (METC/SP--79/6, pp 3-13) STATUS REPORT OF THE EASTERN GAS SHALES PROJECT. Wise, R.L. (Morgantown Energy Technology Center, WV). 1979.

From 3. Eastern gas shales symposium; Morgantown, WV, USA (1 Oct 1979).

Unconventional sources of natural gas already provide over 1 TCF annually to domestic gas production and could ultimately provide a much larger share of the natural gas supply. As a result of the studies being carried out through the Eastern Gas Shales Project (EGSP), the eastern Devonian Shales should make a significant, near-term contribution to the nation's natural gas supply. This paper presents project progress and status of field and laboratory studies for the Resource Characterization, Extraction Technology R and D, Technology Testing and Verification and Project Integration aspects of the EGSP.

23 (TID--28867) BLACK SHALE STUDIES IN KENTUCKY. QUARTERLY REPORT, JUNE 1978. (Kentucky Univ., Lexington (USA)). 1978. Contract EY-76-C-05-5202. 70p. Dep. NTIS, PC A04/MF A01.

Results of the studies are presented in sections on geochemical characterization including mineralogic analyses, elemental analyses, and radioelement determinations. Work devoted to stratigraphic studies is reported in sections on surficial stratigraphy and core archiving. (JRD)

24 (UCRL--52687) OIL SHALE RESOURCE ASSESSMENT FOR IN SITU RETORTING, PHASE 1: PICEANCE CREEK BASIN, COLORADO. Carpenter, R.H.; Gentry, D.W.; Krum, G.L. (California

Univ., Livermore (USA). Lawrence Livermore Lab.). 22 Mar 1979. Contract W-7405-ENG-48. 79p. Dep. NTIS, PC A05/MF A01.

It was decided that the resource potential could best be shown by delineating zones or areas that contained a given thickness of oil shale at various grades. Thicknesses in multiples of 400 ft were chosen for the assessment. Oil shale grades were contoured for specific thickness intervals. The study suggested that the Piceance Creek Basin has a large resource base, with physical dimensions and qualities amenable to in situ processing. A conservative estimate revealed some 384 billion barrels of oil in thickness intervals of greater than or equal to 400 ft and some 309 billion barrels in thicknesses of greater than or equal to 1600 ft. These calculations of the resource base may represent only a fraction of the total within the basin.

25 COAL AND SHALE: ALTERNATIVE FUELS FOR THE MIDTERN. Mills, G.A. (Dept. of Energy, Washington, DC). pp 229-245 of Exploration and economics of the petroleum industry. Volume 16. New ideas, new methods, and new developments. Landwehr, M.L. (ed.). New York, NY; Matthew Bender and Company, Inc. (1978).

From Institute on petroleum exploration and economics; Dallas, TX, USA (8 Mar 1978).

To help develop energy policy and establish a RD and D program the demand/supply situation for a variety of constraints; was analyzed by setting up models. Several conclusions were made: (1) coal and oil shale resources are very large; (2) synthetic liquids from coal and shale are needed; (3) under present conditions of technology and economic incentives, synthetic liquids production from coal will be small, even in the year 2000; (4) synthetic liquids from oil shale are projected to be closer to world oil market prices but have to satisfy environmental constraints; (5) the DOE coal liquefaction program is moving forward rapidly; (6) to achieve significantly lower synthetic liquid costs will require a new emphasis on exploratory research to discover new processes; and (7) new evaluations of the socioeconomic situation could generate economic incentives or mandatory regulations which could greatly accelerate synthetic fuels manufacturing in the United States. 10 figures.

SITE GEOLOGY AND HYDROLOGY

26 (FE--2346-30) STRATIGRAPHIC CROSS SECTIONS EXTENDING FROM DEVONIAN ANTRIM SHALE TO MISSISSIPPIAN SUNBURY SHALE IN THE MICHIGAN BASIN. Ells, G.D. (Michigan Dept. of Natural Resources, Lansing (USA). Geological Survey Div.). Nov 1978. Contract EX-76-C-01-2346. 212p. Dep. NTIS, PC A10/MF A01.

The Devonian shales of the eastern United States are a potential source for tremendous volumes of liquid and gaseous hydrocarbons. The Antrim Shale of Michigan is a part of this extensive body of rock. As part of the Shale Characterization Program, stratigraphic cross sections showing the Antrim Shale and associated formations have been constructed for various parts of the Michigan Basin. The principal formations include the Antrim Shale of Devonian age, the Ellsworth Shale which correlates primarily with the Antrim Shale but whose uppermost part appears to correlate with parts of certain formations of Mississippian age, and the Bedford Shale, Berea Sandstone and Sunbury Shale of eastern Michigan. The Bedford Shale immediately overlies the Antrim in eastern Michigan. Regional cross sections are constructed from gamma ray logs as illustration of the stratigraphic associations of these Devonian and Mississippian formations in the Michigan Basin. Data from gamma ray logs and records of 99 individual wells distributed throughout the Southern Peninsula of Michigan were used to construct six cross sections, and a network of intersecting cross sections which illustrates depths, thicknesses, and the stratigraphic relationship of the subject formations in various sectors of the Basin.

27 (FE--8214-5) COORDINATION OF STUDY OF THE DEVONIAN BLACK SHALE IN THE ILLINOIS BASIN (ILLINOIS, INDIANA, AND WESTERN KENTUCKY). QUARTERLY PROGRESS REPORT, 1 JULY TO 30 SEPTEMBER, 1978--3 OCTOBER 1978. Lineback, J.A. (Illinois State Geological Survey, Urbana (USA)). Oct 1978. Contract EW-78-S-21-8214. 11p. Dep. NTIS, PC A02/MF A01.

Coordination is being performed on data being collected, organized, and stored for the DOE Devonian black shale project. Results of coordination of the work by contractors will be a plan to create a data base for the Devonian black shale in the Illinois Basin. Part of the coordination will be the extensions of the ILLIMAP computer mapping system to parts of Indiana and Kentucky that lie within the Illinois Basin. (DLC)

28 (FE--8214-5-T1) COORDINATION OF STUDY OF THE DEVONIAN BLACK SHALE IN THE ILLINOIS BASIN (ILLINOIS, INDIANA, AND WESTERN KENTUCKY). ANNUAL PROGRESS REPORT, FEBRUARY 1, 1978--JANUARY 31, 1979. Lineback, J.A. (Illinois State Geological Survey, Urbana (USA)). 1 Feb 1979. Contract EW-78-S-21-8214. 22p. Dep. NTIS, PC A02/MF A01.

This report presents some of the highlights of the New Albany Shale study in the Illinois Basin. A large data base is being generated for future workers to use. Evaluation of much of the data collected has yet to be attempted. Many more data and interpretations of those data will become available before the end of the project. With the exception of the aforementioned problems in the distribution and availability of core, no significant voids in the data being developed are seen. The data being collected will be more than adequate to evalute the potential of the New Albany as a conventional source of natural gas in the Illinois Basin.

29 (MERC/SP--77/5, pp 1-21) UNCONVENTIONAL GAS RESOURCES: DOE PROGRAM IN ENHANCED GAS RECOVERY. Smith, J.B. (Department of Energy, Washington, DC). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

A synopsis is given of the overall DOE program in enhanced gas recovery. The program includes the Eastern Gas Shales Project, Western Gas Sands Project, methane from coal beds, and geopressurized aquifers. (DLC)

30 (MERC/SP--77/5) FIRST EASTERN GAS SHALES SYMPOSIUM. Schott, G.L.; Overbey, W.K. Jr.; Hunt, A.E.; Komar, C.A. (eds.). (Department of Energy, Morgantown, WV (USA). Morgantown Energy Research Center). Mar 1978. 794p. (CONF-771038--). Dep. NTIS, PC A99/MF A01.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

Purpose of this symposium is to allow those associated with the Eastern Gas Shales Project (for increased production of natural gas) to report the results of laboratory and field R and D studies conducted during the past year.

The 53 papers and abstracts are arranged under the following headings: general session I, stratigraphy/geology, characterization/physical-mineralogical, general session II, geology/structure, geochemistry-gas and organic, and other papers. Separate abstracts were prepared for 38 papers. (DLC)

31 (ORO--5202-T1) BLACK SHALE STUDIES IN KENTUCKY. ANNUAL REPORT, OCTOBER 1, 1977--SEPTEMBER 30, 1978. Blackburn, W.H. (comp.). (Kentucky Geological Survey, Lexington (USA). Dept. of Geology; Kentucky Geological Survey, Lexington (USA)). 1978. Contract EY-76-C-05-5202. 335p. Dep. NTIS, PC A15/MF A01.

Black shale studies have focussed on their geochemistry, stratigraphy, and subsurface characterization, and on the compilation of an archive of cored material. Technical progress made in these areas are reported. In addition, two Master's theses prepared under the stratigraphic study project and one under the geochemical study project are included and are abstracted and indexed separately. (JSR)

32 (ORO--5203-9) GEOLOGIC AND GEOCHEMICAL STUDIES OF THE NEW ALBANY GROUP (DEVONIAN BLACK SHALE) IN ILLINOIS TO EVALUATE ITS CHARACTERISTICS AS A SOURCE OF HYDROCARBONS. THIRD QUARTERLY PROGRESS REPORT, APRIL 1--JUNE 30, 1978. Bergstrom, R.E.; Shimp, N.F. (Illinois State Geological Survey, Urbana (USA)). 1978. Contract EY-76-C-05-5203. 51p. Dep. NTIS, PC A04/MF A01.

This project is a detailed analysis of the lithology, stratigraphy, and structure of the New Albany Group in Illinois to determine those characteristics of lithology, thickness, regional distribution, vertical and lateral variability, and deformation that are most relevant to the occurrence of hydrocarbons.

33 (SAND--79-0133) CAPABILITIES AND STATUS REPORT OF 4734 MOBILE FIELD SUPPORT UNIT. Beasley, R.R.; Jacobson, R.D.; Uhl, J.E. (Sandia Labs., Albuquerque, NM (USA)). May 1979. Contract EY-76-C-04-0789. 16p. Dep. NTIS, PC A02/MF A01.

This report describes the Mobile Field Support Unit (MFSU) which was procured for well logging, site and formation evaluation tools and measurement techniques in oil shale projects. The status and capabilities of the MFSU are described along with plans for additional capabilities.

34 (SAND--79-0400C) DYNAMIC FRACTURE STRENGTH OF OIL SHALE UNDER TORSIONAL LOADING. Lipkin, J.; Jones, A.K. (Sandia Labs., Albuquerque, NM (USA)). 1979. Contract EY-76-C-04-0789. 19p. (CONF-790606--3). Dep. NTIS, PC A02/MF A01.

From 20. US symposium on rock mechanics; Austin, TX, USA (3 Jun 1979).

A torsional split Hopkinson bar is used to investigate the fracture strength of a nominally lean grade of oil shale at strain rates between approx. 20/s and approx. 800/s. To achieve homogeneous stress and deformation states, the test samples are relatively small thin-walled tubes. The axes of these samples are both parallel and perpendicular to the material bedding planes. Under dynamic torsional loading, sample response is divided into two phases. An initial, essentially linear phase, ending at a shear stress level, Tau/sub y/; and a second phase characterized by a substantially reduced specimen stiffness. Analysis of the failure process has revealed that Tau/sub y/ is essentially the tensile fracture initiation stress level for the material, whereas sample response in the second phase cannot be simply correlated with material behavior. The test results establish that Tau/sub y/ is a strong function of strain rate, however no clear evidence of fracture strength depending on bedding plane orientation is revealed.

35 (TID--29376) SHALE CHARACTERIZATION AND RESOURCE APPRAISAL OF THE DEVONIAN BLACK SHALES OF THE APPALACHIAN BASIN. QUARTERLY REPORT, OCTOBER--DECEMBER 1978. (Geological Survey, Reston, VA (USA)). 1978. Contract EX-76-C-01-2287. 4p. Dep. NTIS, PC A02/MF A01.

Activities are reported in a program designed to characterize the gas-productive and potentially gas-productive brown and black carbonaceous shales and related rocks of Middle and Late Devonian age in the Appalachian basin using data developed in the stratigraphy, structure, mineralogy, paleontology, geochemistry, geophysics, and hydrocarbon productivity of these rocks; to develop a comprehensive paleogeographic model of the basin of accumulation and the environment of deposition for the Devonian shales and related rocks; to assist the Department of Energy's Morgantown Energy Technology Center by monitoring and coordinating efforts of other Eastern Gas Shales Project cooperators in stratigraphic studies; to respond to specific requests by METC to data germaine to the shale characterization study; to develop a data system capable of storing for retrieval the many diverse data generated in the EGS project in the Appalachian basin; and to make a resource appraisal of the energy potential of the Devonian brown and black shales in the Appalachian basin.

36 MINERAL AND ORGANIC RELATIONSHIPS THROUGH COLORADO'S GREEN RIVER FORMATION ACROSS ITS SALINE DEPOSITIONAL CENTER. Robb, W.A.; Smith, J.W. (Energy Research and Development Administration, Laramie, WY). pp 136-147 of Tenth oil shale symposium proceedings. Reubens, J.B. (ed.). Golden, CO; Colorado School of Mines (1977).

From 10. oil shale symposium; Golden, CO, USA (21 Apr 1977).

Stratigraphically correlated profiles of organic matter concentration and the distribution and relative abundance of 8 major minerals in oil shales, through Colorado's Green River Formation near its saline depositional center, were used to evaluate relationships among these components in Colorado oil shales. Strong direct relationships were found between the volume of organic matter and the amounts of the silicate minerals. The silicate minerals were also directly related to each other. Dawsonite, in the saline zone of the Formation, was also directly related to the volume of organic matter and, indirectly, to the amount of nahcolite. These relationships were all interpreted as resulting from CO_2 arising from organic matter in the sediment. A strong direct relationship, demonstrated between dawsonite and quartz, was credited to both the organic CO_2 mechanisms and to ashfall decomposition. Significant noncorrelation with organic matter or any of the other minerals was found for calcite and analcime. Lack of significant correlation among any of the components in a particular horizon demonstrated absence of geochemical control during its deposition. 3 figures, 5 tables.

SITE GEOLOGY

37 (DOE/IA--0002/02) JOINT EGYPT/UNITED STATES REPORT ON EGYPT/UNITED STATES COOPERATIVE ENERGY ASSESSMENT. VOLUME 2 OF 5 VOLS. ANNEX 1. (Department of Energy, Washington, DC (USA)). Apr 1979. 215p. Dep. NTIS, PC A10/MF A01.

Detailed summaries are presented of Egypt's indigenous energy resources from the U.S. Geological Survey assessments; preliminary information collected early in 1977 from files, reports, and publications existing in the U.S.; and data gathered during one-month assessment program in March--April 1978. Detailed reports are given on oil and gas, coal and oil shale, uranium and thorium, geothermal energy, water resources, and energy-related minerals/ commodities. An assessment of cement-making materials, iron ore, manganese, aluminium, barite, bentonite, copper, chromium, nickel, titanium, and miscellaneous metals used in steel making is presented.

38 (DOE/MC/05205--T2) CHARACTERIZATION AND ANALYSIS OF DEVONIAN SHALES AS RELATED TO RELEASE OF GASEOUS HYDROCARBONS. WELL O-1 CHRISTIAN COUNTY, KENTUCKY. Kalyoncu, R.S.; Boyer, J.P.; Snyder, M.J. (Battelle Columbus Labs., OH (USA)). 25 May 1979. Contract DE-AC21-76MC05205. 39p. Dep. NTIS, PC A03/MF A01.

Partial data on the characterization of Well O-1 (Christian County, Kentucky) shales were first reported in the Fifth Quarterly Technical Progress Report on January 1978. This report presents all the characterization data and its analysis on the O-1 shales. Coring of Well O-1 was accomplished in October 1976. A total of 17 samples were obtained, 13 for Battelle and 4 for other DOE Contractors. Methane is almost the sole hydrocarbon gas present in these shales, with higher chain hydrocarbon gases nearly nonexistent. An apparent increase in hydrocarbon gas contents with shale depth is observed. Other organic contents (in the form of carbon and hydrogen) also show an increase with increasing shale depth. An increase in hydrocarbon gas contents with carbon and hydrogen contents is also noticeable. Natural gas, carbon and hydrogen contents all vary inversely with bulk densities. O-1 shales show low mercury intrusion porosities and very low to negligible gas permeabilities. Lithology of these shales is very similar to those previously reported, quartz being the most abundant single mineral. Illite and kaolin are the major clay minerals with a number of carbonates (nahcolite, sortite, siderite) present in moderate quantities. Pyrite is also observed in significant quantities.

39 (DOE/MC/05205--T3) CHARACTERIZATION AND ANALYSIS OF DEVONIAN SHALES AS RELATED TO RELEASE OF GASEOUS HYDROCARBONS. WELL C-336 MARTIN COUNTY, KENTUCKY. Kalyoncu, R.S.; Boyer, J.P.; Snyder, M.J. (Battelle Columbus Labs., OH (USA)). 16 May 1979. Contract DE-AC21-76MC05205. 61p. Dep. NTIS, PC A04/MF A01.

Partial data on the characterization of C-336 (Martin County, Kentucky) shales were reported in the Sixth Quarterly Technical Progress Report, January through March 1978. Total characterization data and interpretation are presented in this Individual Well Report on shales from Well C-336 (Ky No. 3). Coring of C-336 well was accomplished in November 1976. Samples were obtained at depths from 2479 to 3371 feet. 119 samples were collected for Battelle and 90 for other DOE contractors. Shales from Well C-336 exhibit relatively high hydrocarbon gas contents. Oxygen to nitrogen ratios in the gas analysis continue to be very low, leading to various possibilities mentioned in previous reports. Wide range in carbon contents characterizes the chemical composition of the organics in these shales. Positive relationships exist between the hydrocarbon gas contents and chemical data (carbon and hydrogen). Relationships between the physical data and gas contents are not as distinct, though, an inverse relationship does exist between the bulk density and hydrocarbon gas contents.

40 (FE--2287-T5) SHALE CHARACTERIZATION AND RESOURCE APPRAISAL OF THE DEVONIAN BLACK SHALES OF THE APPALACHIAN BASIN. QUARTERLY REPORT, APRIL--JUNE 1978. de Witt, W. Jr. (Geological Survey, Reston, VA (USA)). 1978. Contract EX-76-A-01-2287. 21p. Dep. NTIS, PC A02/MF A01.

Activities are reported in a program to characterize the gas-productive black shales and related rocks of Middle and Late Devonian age in the Appalachian basin by use of stratigraphic, paleontologic, geochemical, mineralogic, and geophysical data; to assist DOE--MERC by coordinating and evaluating stratigraphic work in shale characterization studies by other DOE--Eastern Gas Shales Cooperators to the limit of available USGS personnel; to develop a data storage and retrieval system to store the data generated in the EGS project, to make a resource appraisal of the hydrocarbon potential of the Devonian black shales of the Appalachian basin using data generated in part by the USGS, in part by DOE--MERC and in part by EGS project contractors; to conduct work shops for other EGS project cooperators in stratigraphy, structure, geochemistry, and mineralogy as the occasion demands; and to assist in technology transfer by participating as panel-of-interest members at DOE - Industry meetings.

41 (FE--2287-T8) CHARACTERIZATION AND RESOURCE APPRAISAL OF THE DEVONIAN BLACK SHALES OF THE APPALACHIAN BASIN. de Witt, W. Jr. (Geological Survey, Washington, DC (USA)). 1979. Contract EX-76-A-01-2287. 4p. Dep. NTIS, PC A02/MF A01.

The status of the program to characterize the dark-brown to black carbonaceous gas-productive and potentially gas-productive shales and associated rocks of middle and late Devonian age in the Appalachian basin using data developed from the stratigraphy, structure, geophysics, paleontology, geochemistry and hydrocarbon productivity of the strata is described briefly.

42 (FE--2346-32) X-RAY MINERALOGY AND PHYSICAL PROPERTIES OF ANTRIM SHALE SAMPLES FROM SANILAC CO., MICHIGAN. Hockings, W.A.; Ruotsala, A.P.; Bennett, G.W. (Michigan Technological Univ., Houghton (USA). Dept. of Geology and Geological Engineering). Mar 1979. Contract EX-76-C-01-2346. 53p. Dep. NTIS, PC A04/MF A01.

This report describes mineralogical determinations and physical properties of core samples from wells 100, 101, and 102 located on Dow Chemical Company property in Fremont Township, Sanilac County, Michigan. Mineralogical determinations were made by x-ray powder diffraction. Quantitative results were obtained by comparison with prepared standards. Physical properties measured include density, porosity, pore size distribution, permeability,

and specific surface. These properties were measured on natural samples and on samples which had been roasted in nitrogen and in air. Weight and dimensional changes produced by roasting were also measured.

43 (FE--5194-T1) QUARTERLY PROGRESS REPORT, JANUARY--MARCH, 1979. Shumaker, R.C.; de Wys, J.N.; Dixon, J.M.; Evans, M.A.; Kirk, K.G.; Lee, K.D.; Long, B.R.; Rauch, H.W.; Ructsala, J.E.; Wilson, T.H. (West Virginia Univ., Morgantown (USA). Dept. of Geology and Geography). 1979. Contract EY-76-C-05-5194. 27p. Dep. NTIS, PC A03/MF A01.

Iso-potential maps were completed for the eastern Kentucky shale gas field. Delays are being encountered in the geophysical and fracture studies. Other work include structure contour maps, structure studies, etc. (DLC)

44 (LA--7523-PR) STIMULATION AND CHARACTERIZATION OF EASTERN GAS SHALES. PROGRESS REPORT, JANUARY--MARCH 1978. Schott, G.L. (comp.). (Los Alamos Scientific Lab., NM (USA)). Dec 1978. Contract W-7405-ENG-36. 26p. Dep. NTIS, PC A03/MF A01.

The progress of investigations is reported on the use of metal-lined shaped charges for the explosive stimulation of natural gas wells in Devonian shales, and the use of rapid analysis by laser-pyrolysis/gas-chromatography to determine geochemical characteristics of these shales. Results are presented of small-scale tests that measure the penetration of several shales and grouts by a standard commercial shaped charge. A grout composition of Portland cement with ferrophosphorus sand has been found that simulates the penetrability of shale satisfactorily for continued development work on our tapered liner charges of wellbore scale. Shock wave Hugoniot data observed in planar impact experiments on Devonian shale core specimens have been systematized for future high-pressure penetration dynamics calculations. The theoretical model used includes mechanical unloading hysteresis and high release-wave speed. Using controlled techniques devised for analyzing homogenized shale powders, a preliminary correlation was achieved between the absolute yield of acetylene from pulsed-laser pyrolysis and the independently measured total carbon content.

45 (LETC/RI--78/6) MINERAL AND ORGANIC DISTRIBUTIONS AND RELATIONSHIPS ACROSS THE GREEN RIVER FORMATION'S SALINE DEPOSITIONAL CENTER, PICEANCE CREEK BASIN, COLORADO. Robb, W.A.; Smith, J.W.; Trudell, L.G. (Department of Energy, Laramie, WY (USA). Laramie Energy Technology Center). Sep 1978. 44p. Dep. NTIS, PC A03/MF A01.

Stratigraphically correlated profiles of organic matter concentration and profiles of 8 major mineral x-ray diffraction peak heights in oil shales, through Colorado's Green River Formation near its saline depositional center, are presented in histogram form. The profiles are used to show distributions and relationships of the minerals and organic matter. Strong direct relationships between the volume of organic matter in Colorado's Green River Formation oil shales and the relative amounts of the silicate minerals--quartz, soda feldspar, and potash feldspar-- were demonstrated singly and collectively. The silicate minerals were also shown to be directly related to each other. Dawsonite in the saline zone of the Formation was also shown to be directly related to the volume of organic matter and indirectly to the amount of nahcolite. These relationships were all interpreted as the results of CO_2 evolution from organic matter in the sediment. A strong direct relationship demonstrated between dawsonite and quartz was credited to both the organic CO_2 mechanisms and to ash-fall decomposition. Significant non-correlation with organic matter or any of the other minerals was found for calcite and analcime. Lack of significant correlation among any of the components in one particular section demonstrated absence of geochemical control during its deposition. The relationships provide an additional interpretive tool for the Green River Formation.

46 (MERC/SP--77/5, pp 620-633) CONODONT COLOR ALTERATION, AN ORGANO-MINERAL METAMORPHIC INDEX, AND ITS APPLICATION TO APPALACHIAN BASIN GEOLOGY. Harris, A.G. (Geological Survey, Laurel, MD). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

Condonts are apatitic marine microfossils of Cambrian through Triassic age. During incipient metamorphism (50° to 300°C) they change color from pale yellow to brown to black due to carbon-fixing within the trace amount of organic matter in their skeletons. As thermal metamorphism continues (300° to 550°C), conodonts change from black to gray to white to crystal clear as a result of carbon loss, release of water of crystallization, and recrystallization. The conodont color alteration technique provides a unique link between mineral and organic indexing of thermal metamorphism and is best suited for carbonate rocks. Conodont color alteration index (CAI) isograd maps for three stratigraphic intervals in the Appalachian basin show: (1) The alteration is directly related to the depth and duration of burial and the geothermal gradient. (2) Tectonics affect color alteration only where folding and faulting act to significantly increase depth of burial. (3) Isograds and overburden isopachs are conformable throughout most of the northern half and in the western part of the southern Appalachian basin. (4) South of central Virginia, isograds are disrupted and irregular. (5) Basin restoration using conodont CAI isograds indicates a maximum shortening in northeast Tennessee of about 115 miles (185 km). (6) The CAI 2 isograd (= brown conodonts) for each stratigraphic interval lies near the eastern limit of oil production for that interval. (7) Gas production is less related to isograds and depends mostly on primary and (or) secondary porosity and permeability. 8 figures, 1 table.

47 (MERC/SP--77/5, pp 23-36) UPDATE CONCERNING THE THREE-DIMENSIONAL SEISMIC INVESTIGATIONS IN THE COTTAGEVILLE FIELD. Tegland, E.R. (Geophysical Services, Inc., Dallas, TX). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

In June 1977, Geophysical Service Inc. undertook an ERDA sponsored three-dimensional seismic program in the Cottageville field in conjunction with Consolidated Gas Supply Corporation. The program was aimed at defining the seismic characteristics of the Devonian shale section and accurately mapping deep seated faults which might control fracturing and production in the shale. The complete results available as of September 1, 1977, are presented. 9 figures.

48 (MERC/SP--77/5, pp 183-194) NEW ALBANY SHALE AND CORRELATIVE STRATA IN INDIANA.

Bassett, J.L.; Hasenmuller, N.R. (Indiana Geological Survey, Bloomington). Mar 1978.
From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).
The New Albany Shale has a maximum thickness of 337 feet in southwestern Indiana and thins northward and eastward to about 90 feet in the outcrop area. In the Michigan Basin, strata equivalent to the New Albany are 348 feet thick in Lagrange County. The base of the New Albany is 4,500 feet below sea level in southwestern Indiana, and the base of the Antrim Shale is 150 feet above sea level in northern Indiana (Lagrange County). In the Illinois Basin the New Albany is divided into four members: the Hannibal, Grassy Creek, Sweetland Creek, and Blocher Shales. The lithologic equivalents of the New Albany in the Michigan Basin are the Sunbury, Ellsworth, and Antrim Shales. The New Albany produced commercial gas from seven fields in Harrison County and one field in Martin County. Two small gas fields have been found in the New Albany in Daviess County. 6 figures.

49 (MERC/SP--77/5, pp 297-310) GEOCHEMICAL CHARACTERIZATION OF THE DEVONIAN BLACK SHALE FROM COTTAGEVILLE, WEST VIRGINIA: A PRELIMINARY LOOK AT MULTIVARIATE ANALYSIS. Bialobok, S.J. (Morgantown Energy Research Center, WV); Lamey, S.C.; Sumartojo, J. Mar 1978.
From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).
R-mode cluster analysis of geochemical data obtained from the Cottageville wells No. 11940 and No. 12041 groups the data into nine clusters. The results indicate "key" geochemical variables which may be analyzed to characterize the Devonian shale. Of the 43 geochemical and mineralogical parameters analyzed by regression analysis from well No. 11940, nine show variations with depth. Specific gravity, moisture, organic sulfur, copper, barium, Fe_2O_3, and Na_2O have negative correlations with depth; whereas boron and chlorite have positive correlations with depth. 2 figures, 3 tables.

50 (MERC/SP--77/5, pp 311-327) PETROLOGIC STUDY OF THE DEVONIAN SHALES FROM CENTRAL TENNESSEE AND WEST VIRGINIA. Sumartojo, J. (Vanderbilt Univ., Nashville, TN); Waldstein P. Mar 1978.
From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).
The X-ray mineralogy of the Devonian black shales collected from outcorps in central Tennessee and drillings in Kentucky and West Virginia, is simple and fairly uniform. The mineral assemblage consists mainly of chlorite, illite (muscovite), and quartz, with minor amounts of feldspars, carbonates, and pyrite. Petrographic and scanning electron microscopic (SEM) examinations show the occurrence of organic matter (spore, kerogen, bitumen, and woody fragments) and minerals such as gypsum, pyrite, halite, albite, sphalerite, calcium phosphate. SEM observations also show the presence of spaces among the phyllosilicate platelets and the authigenic minerals, and in the fine cracks. Furthermore the size and distribution of quartz grains can be revealed by using an SEM. 10 figures.

51 (MERC/SP--77/5, pp 328-354) PETROLOGY OF NEW ALBANY SHALE GROUP (UPPER DEVONIAN AND KINDERHOOKIAN) IN THE ILLINOIS BASIN, A PRELIMINARY REPORT. Harvey, R.D.; White, W.A.; Cluff, R.M.; Frost, J.K.; DuMontelle, P.B. (Illinois State Geological Survey, Urban). Mar 1978.
From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).
Studies of two cores through the New Albany Group of Upper Devonian and Kinderhookian (lower Mississippian) age in Christian County, Kentucky, and Sangamon County, Illinois, based on radiography of slabs and petrography of thin sections, permit classification of the shale strata into several distinct lithofacies. Lithofacies are defined on the basis of color, the character of laminations, synaeresis distribution and amount of pyrite, silt and carbonate constituents, spore content, and small scale sedimentary and biogenic structures. Correlations are examined between various lithofacies and the occurrence and the properties of internal surface area, the clay orientation, and other physical properties of the shales. Lithofacies provide a basis for interpreting the environments of deposition. 10 figures, 8 tables.

52 (MERC/SP--77/5, pp 434-441) PALECURRENT SYSTEMS IN SHALY BASINS: PRELIMINARY RESULTS FOR APPALACHIAN BASIN (UPPER DEVONIAN). Kepferle, R.C. (Geological Survey, Cincinnati, OH); Lundegard, P.; Maynard, J.B.; Potter, P.E.; Pryor, W.A.; Samuels, N.; Schauf, F.J. Mar 1978.
From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).
Studies of paleocurrent systems in shaly basins can be made (1) by examining the paleocurrent structures of the siltstones, sandstones, and carbonate deposits that are minor constituents of most shaly basins; (2) possibly by studying shale fabrics as seen by the Scanning Electron Microscope and other methods; and (3) by mapping scalar variables such as the C_{13}/C_{12} ratio (marine versus terrestrial carbon) within the shale itself. A summer's fieldwork studying outcrops and oriented cores of the Upper Devonian shale sequence of the Appalachian basin illustrates many of the above dividends that result from paleocurrent studies of shaly basins--one of sedimentology's unexploited fields. 4 figures.

53 (MERC/SP--77/5, pp 476-523) ANALYSIS OF STRUCTURAL GEOLOGICAL PARAMETERS THAT INFLUENCE GAS PRODUCTION FROM THE DEVONIAN SHALE OF THE APPALACHIAN BASIN. Shumaker, R.C.; Kirk, K.G.; Nuckols, E.B. III; Long, B.R. (West Virginia Univ., Morgantown). Mar 1978.
From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).
The project is designed to: (1) document fracture patterns and structural deformation within and around areas of Devonian shale production; (2) evaluate inexpensive geophysical and remote sensing techniques to locate potentially productive fracture zones; and (3) study production within producing fields for comparison with adjacent non-productive areas to assess the influence of structure on production. Work was initiated this year on: (1) regional analysis of basin structure, (2) compilation of surface fractures from eastern Kentucky and West Virginia, (3) shallow high frequency seismic and resistivity studies to locate fracture zones, and (4) groundwater studies above the Cottageville Devonian shale gas field for comparison with a production study of that same field. 16 figures.

54 (MERC/SP--77/5, pp 381-388) DYNAMIC PROPERTIES OF DEVONIAN SHALES. Carter, W.J.; Olinger, B.W. (Los Alamos Scientific Lab., NM). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

Successful prediction and optimization of explosive effects in geologic materials requires a thorough knowledge of the constitutive relations governing the rock response to impulsive loading. Such constitutive relations must include descriptions of both wave propagation and fracture phenomena under dynamic stress. The initial phase of our program therefore has been directed toward acquiring these basic data. Some of the dynamic properties of gas shales and the techniques used to determine them are discussed. 3 figures.

55 (MERC/SP--77/5, pp 642-658) PETROLOGY OF LOWER HURON DEVONIAN SHALE, COLUMBIA GAS TRANSMISSION CO. WELL NO. 20403, LINCOLN COUNTY, WEST VIRGINIA. Vinopal, R.J. (West Virginia Geological and Economic Survey, Morgantown). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

Petrographic analyses indicate that the seemingly homogeneous Lower Huron ''brown shale'' consists of several distinguishable units based upon composition, density, and fabric. Organic constituents occur as structured bodies (spores, shreddy material, cuticles) and as fine-grained and amorphous matter which commonly coats grains and contributes to the rock matrix. Quartz, illite, and kaolinite comprise in excess of 90% of the total mineral constituents. Pyrite, dolomite, and calcite are common authigenic minerals. Bulk densities determined on core samples commonly differ from values on the density log. Parameters to explain these differences remain under investigation. Thin parallel laminae defined by changes in composition, texture, and color are the most abundant primary sedimentary structures. Fabric elements include orientation of clay laths, silt lenses, and interspersed silt grains which disrupt packing of the clay laths. Increasing amounts of silty lenses might be expected to produce increased permeability in the bulk rock, but compaction or authigenic mineral growth may alter this simple relationship. 14 figures.

56 (METC/CR--79/2) DEVONIAN SHALES OF OHIO AND THEIR EASTERN AND SOUTHERN EQUIVALENTS. Schwietering, J.F. (West Virginia Geological and Economic Survey, Morgantown (USA)). Jan 1979. Contract EY-76-C-05-5199. 72p. Dep. NTIS, PC A04/MF A01.

Devonian shale units recognized in outcrops in Ohio can be identified in the subsurface of eastern Ohio and eastern Kentucky and can be traced into Pennsylvania, New York, and West Virginia by means of gamma ray-neutron and sample-description logs. An unconformity separates the Olentangy Shale into two parts; the lower part is equivalent to part of the Hamilton Group of the eastern states, the upper part is equivalent to the Java and West Falls Formations of New York. The unconformity within the Olentangy Shale is the same as the unconformity separating the Tully Limestone from the underlying Hamilton Group in the eastern areas. The Ohio Shale of Ohio is equivalent to the Conewango, Conneaut, and Canadaway Groups of New York and the Chattanooga Shale of Kentucky.

57 (METC/CR--79/22) DEVONIAN PALEOCURRENTS OF THE APPALACHIAN BASIN. Potter, P.E.; Pryor, W.A.; Lundegard, P.; Samuels, N.; Maynard, J.B. (Cincinnati Univ., OH (USA). H.N. Fisk Lab. of Sedimentology). May 1979. 66p. Dep. NTIS, PC A04/MF A01.

The paleocurrent system of the Devonian clastics of the central and northern Appalachian basin is uniformly oriented to the west judging by the orientation of sole marks on interbedded siltstones and sandstones and by the available directional data from interbedded black and gray shales. Paleocurrent indicators are at right angles to isopach of total Devonian thickness, which decreases westward from 12,000 ft. in eastern Pennsylvania to a few hundred feet in west-central Ohio. This clastic wedge is largely of Upper Devonian age and includes alluvial and delta plain environments (in the east) as well as shelf (east-central), turbidite slope, and basin plain environments (west-central and west), the latter representing most of the black shales. Lithologies within the wedge are more continuous north-south parallel to depositional strike than east-west. The gradient of carbon isotopes, which shows more marine than terrestrial carbon in the western part of the basin, closely parallels the average paleocurrent direction of the basin. The methodology of paleocurrent studies in shaly basins based on both outcrops and oriented cores, is set forth as is the relationship between paleocurrents and gas potential.

58 (METC/CR--79/26) PROCEDURES FOR PETROPHYSICAL, MINERALOGICAL AND GEOCHEMICAL CHARACTERIZATION OF FINE-GRAINED CLASTIC ROCKS AND SEDIMENTS. Nuhfer, E.B.; Florence, J.A.; Clagett, J.L.; Renton, J.J.; Romanosky, R.R. (Department of Energy, Morgantown, WV (USA). Morgantown Energy Technology Center). Aug 1979. Contract EY-76-C-05-5199. 41p. Dep. NTIS, PC A03/MF A01.

The methods result from about four years of study of shales and recent fine-grained muds and are suitable for rapidly processing large numbers of samples cheaply and quickly with very good precision. Density and porosity measurements sufficient to provide good between-sample comparisons of shales with only about 1 or 2% porosity are possible using equipment found in most laboratories providing that attention is given to sources of small errors and suitable immersion fluids are used. Mineralogical composition can be precisely characterized by x-ray diffraction, providing that a careful sample preparation scheme is adhered to. Such precision can be maintained on samples as small as 20mg in size. Elemental analyses are better performed on high-temperature ash remaining after loss-on-ignition than on original whole sample. Complete chemical analyses of major, minor, and many trace elements can be obtained on sample sizes as small as 20mg of ash. Precision afforded by mineralogical and chemical methodology is sufficient to allow merging of data from these two sources for statistical analyses. Presence of significant amounts of x-ray-amorphous mineraloids is now thoroughly documented in recent muds and is possibly present in many shales.

59 (METC/CR--79/27) X-RADIOGRAPH ATLAS OF LITHOTYPES AND OTHER STRUCTURES IN THE DEVONIAN SHALE SEQUENCE OF WEST VIRGINIA AND VIRGINIA. Nuhfer, E.B.; Vinopal, R.J.; Klanderman, D.S. (West Virginia Geological and Economic Survey, Morgantown (USA)). Aug 1979. Contract EY-76-C-05-5199. 49p. Dep. NTIS, PC A03/MF A01.

X-radiographs of 525 samples from cored wells and outcrops serve as the basis for a study of fabric elements in the Upper Devonian shale sequence of West Virginia and Virginia. Four shale lithotypes have been identified from X-radiographs: (1) thinly-laminated shale, (2)

lenticularly-laminated shale, (3) sharply-banded shale, and (4) non-banded shale. The order from 1 to 4 follows decreasing lateral fabric continuity. Two non-shale lithotypes, siltstones and concretions are also recognized. Gas production from this shale section is associated with lithotypes possessing high lateral fabric continuity. Thus, a classification based on fabric elements appears useful both for interpretation of depositional environments and for interpretation of reservoir properties. Forty-nine illustrations of lithotypes, other sedimentary structures, and tectonic features are given.

60 (METC/EGSP--1) PRELIMINARY STRATIGRAPHIC CROSS SECTION (C1-C3) SHOWING RADIOACTIVE BLACK SHALE ZONES AND SANDSTONES IN THE MIDDLE AND UPPER DEVONIAN, WESTERN PENNSYLVANIA. Piotrowski, R.G.; Krajewski, S.A. (Pennsylvania Dept. of Environmental Resources, Harrisburg (USA). Bureau of Topographic and Geologic Survey). 1979. Contract EY-76-S-05-5198. 50p. Dep. NTIS, PC A03/MF A01.
DEVONIAN PERIOD;PENNSYLVANIA;GEOLOGY;BLACK SHALES;SANDSTONES;NATURAL RADIOACTIVITY; STRATIGRAPHY

61 (METC/EGSP--2) PRELIMINARY STRATIGRAPHIC CROSS SECTION (A3-D3) SHOWING RADIOACTIVE BLACK SHALE ZONES AND SANDSTONES IN THE MIDDLE AND UPPER DEVONIAN, WESTERN PENNSYLVANIA. Piotrowski, R.G.; Krajewski, S.A. (Pennsylvania Dept. of Environmental Resources, Harrisburg (USA). Bureau of Topographic and Geologic Survey). 1979. Contract EY-76-S-05-5198. 40p. Dep. NTIS, PC A03/MF A01.
DEVONIAN PERIOD;PENNSYLVANIA;GEOLOGY;BLACK SHALES;SANDSTONES;STRATIGRAPHY;NATURAL RADIOACTIVITY;MAPS

62 (METC/EGSP--3) PRELIMINARY STRATIGRAPHIC CROSS SECTION (A2-D2) SHOWING RADIOACTIVE BLACK SHALE ZONES AND SANDSTONES IN THE MIDDLE AND UPPER DEVONIAN, WESTERN PENNSYLVANIA. Piotrowski, R.G.; Krajewski, S.A. (Pennsylvania Dept. of Environmental Resources, Harrisburg (USA). Bureau of Topographic and Geologic Survey). 1979. Contract EY-76-S-05-5198. 40p. Dep. NTIS, PC A03/MF A01.
PENNSYLVANIA;BLACK SHALES;NATURAL RADIOACTIVITY;STRATIGRAPHY;SANDSTONES;DEVONIAN PERIOD;GEOLOGY;MAPS

63 (METC/EGSP--4) PRELIMINARY STRATIGRAPHIC CROSS SECTION (A1-D1) SHOWING RADIOACTIVE BLACK SHALE ZONES AND SANDSTONES IN THE MIDDLE AND UPPER DEVONIAN, WESTERN PENNSYLVANIA. Piotrowski, R.G.; Krajewski, S.A. (Pennsylvania Dept. of Environmental Resources, Harrisburg (USA). Bureau of Topographic and Geologic Survey). 1979. Contract EY-76-S-05-5198. 40p. Dep. NTIS, PC A03/MF A01.
PENNSYLVANIA;GEOLOGY;BLACK SHALES;SANDSTONES; STRATIGRAPHY;MAPS;DEVONIAN PERIOD;NATURAL RADIOACTIVITY

64 (METC/EGSP--5) PRELIMINARY STRATIGRAPHIC CROSS SECTION (C4-D4) SHOWING RADIOACTIVE BLACK SHALE ZONES AND SANDSTONES IN THE MIDDLE AND UPPER DEVONIAN, WESTERN PENNSYLVANIA. Piotrowski, R.G.; Krajewski, S.A. (Pennsylvania Dept. of Environmental Resources, Harrisburg (USA). Bureau of Topographic and Geologic Survey). 1979. Contract EY-76-S-05-5198. 55p. Dep. NTIS, PC A04/MF A01.
PENNSYLVANIA;GEOLOGY;BLACK SHALES;SANDSTONES; STRATIGRAPHY;DEVONIAN PERIOD;MAPS;NATURAL RADIOACTIVITY

65 (METC/EGSP--6) PRELIMINARY STRATIGRAPHIC CROSS SECTION (D3-D4) SHOWING RADIOACTIVE BLACK SHALE ZONES AND SANDSTONES IN THE MIDDLE AND UPPER DEVONIAN, WESTERN PENNSYLVANIA. Piotrowski, R.G.; Krajewski, S.A. (Pennsylvania Dept. of Environmental Resources, Harrisburg (USA). Bureau of Topographic and Geologic Survey). 1979. Contract EY-76-S-05-5198. 50p. Dep. NTIS, PC A03/MF A01.
PENNSYLVANIA;MAPS;GEOLOGY;SANDSTONES;BLACK SHALES;NATURAL RADIOACTIVITY;STRATIGRAPHY; DEVONIAN PERIOD

66 (METC/EGSP--7) PRELIMINARY STRATIGRAPHIC CROSS SECTION (B1-B4) SHOWING RADIOACTIVE BLACK SHALE ZONES AND SANDSTONES IN THE MIDDLE AND UPPER DEVONIAN, WESTERN PENNSYLVANIA. Piotrowski, R.G.; Krajewski, S.A. (Pennsylvania Dept. of Environmental Resources, Harrisburg (USA). Bureau of Topographic and Geologic Survey). 1979. Contract EY-76-S-05-5198. 45p. Dep. NTIS, PC A03/MF A01.
PENNSYLVANIA;GEOLOGY;BLACK SHALES;SANDSTONES; STRATIGRAPHY;NATURAL RADIOACTIVITY;DEVONIAN PERIOD;MAPS

67 (METC/EGSP--8) PRELIMINARY STRATIGRAPHIC CROSS SECTION (D1-D3) SHOWING RADIOACTIVE BLACK SHALE ZONES AND SANDSTONES IN THE MIDDLE AND UPPER DEVONIAN, WESTERN PENNSYLVANIA. Piotrowski, R.G.; Krajewski, S.A. (Pennsylvania Dept. of Environmental Resources, Harrisburg (USA). Bureau of Topographic and Geologic Survey). 1979. Contract EY-76-S-05-5198. 38p. Dep. NTIS, PC A03/MF A01.
PENNSYLVANIA;GEOLOGY;BLACK SHALES;SANDSTONES; STRATIGRAPHY;NATURAL RADIOACTIVITY;MAPS; DEVONIAN PERIOD

68 (METC/EGSP--9) PRELIMINARY STRATIGRAPHIC CROSS SECTION (A1-A4) SHOWING RADIOACTIVE BLACK SHALE ZONES AND SANDSTONES IN THE MIDDLE AND UPPER DEVONIAN, WESTERN PENNSYLVANIA. Piotrowski, R.G.; Krajewski, S.A. (Pennsylvania Dept. of Environmental Resources, Harrisburg (USA). Bureau of Topographic and Geologic Survey). 1979. Contract EY-76-S-05-5198. 40p. Dep. NTIS, PC A03/MF A01.
PENNSYLVANIA;GEOLOGY;BLACK SHALES;SANDSTONES; STRATIGRAPHY;NATURAL RADIOACTIVITY;DEVONIAN PERIOD;MAPS

69 (METC/EGSP--10) DRILLING DEPTH MAP TO THE TOP OF THE MIDDLE DEVONIAN ONONDAGA GROUP. Piotrowski, R.G.; Krajewski, S.A. (Pennsylvania Dept. of Environmental Resources, Harrisburg (USA). Bureau of Topographic and Geologic Survey). 1979. Contract EY-76-S-05-5198. 50p. Dep. NTIS, PC A03/MF A01.
DEVONIAN PERIOD;WELL DRILLING;DEPTH; PENNSYLVANIA;SHALES;MAPS;ROCK DRILLING

70 (METC/EGSP--11) GAS SHOW AND PRODUCTION MAP FROM MIDDLE AND UPPER DEVONIAN ORGANIC RICH SHALES IN WESTERN AND NORTHERN PENNSYLVANIA. Piotrowski, R.G.; Krajewski, S.A. (Pennsylvania Dept. of Environmental Resources, Harrisburg (USA). Bureau of Topographic and Geologic Survey). 1979. Contract EY-76-S-05-5198. 45p. Dep. NTIS, PC A03/MF A01.
PENNSYLVANIA;DEVONIAN PERIOD;MAPS;NATURAL GAS DEPOSITS;SHALES;NATURAL GAS WELLS;GEOLOGY

71 (METC/EGSP--14) STRUCTURE CONTOUR MAP ON TOP OF THE MIDDLE DEVONIAN ONONDAGA GROUP IN WESTERN AND NORTHERN PENNSYLVANIA. Harper,

J.A.; Piotrowski, R.G. (Pennsylvania Dept. of Environmental Resources, Harrisburg (USA). Bureau of Topographic and Geologic Survey). 1979. Contract EY-76-S-05-5198. 48p. Dep. NTIS, PC A03/MF A01.
PENNSYLVANIA;GEOLOGY;MAPS;DEVONIAN PERIOD; BLACK SHALES;STRATIGRAPHY

72 (METC/EGSP--800) MAP SHOWING STRUCTURE ON BASE OF NEW ALBANY SHALE (DEVONIAN AND MISSISSIPPIAN) AND EQUIVALENT STRATA IN INDIANA. Bassett, J.L.; Hasenmueller, N.R. (Indiana State Dept. of Natural Resources, Indianapolis (USA). Geological Survey). 1979. Contract EY-76-C-05-5204. 12p. Dep. NTIS, PC A02/MF A01.
INDIANA;GEOLOGY;SHALES;DEVONIAN PERIOD; MISSISSIPPIAN PERIOD;GEOLOGIC STRATA;GEOLOGIC STRUCTURES

73 (METC/EGSP--801) MAP SHOWING STRUCTURE ON TOP OF NEW ALBANY SHALE (DEVONIAN AND MISSISSIPPIAN) AND EQUIVALENT STRATA IN INDIANA. Bassett, J.L.; Hasenmueller, N.R. (Indiana State Dept. of Natural Resources, Indianapolis (USA). Geological Survey). 1979. Contract EY-76-C-05-5204. 12p. Dep. NTIS, PC A02/MF A01.
BLACK SHALES;SHALES;INDIANA;GEOLOGY;MAPS; DEVONIAN PERIOD;MISSISSIPPIAN PERIOD

74 (METC/EGSP--804) MAP OF INDIANA SHOWING REPORTED OIL AND GAS SHOWS FROM MIDDLE DEVONIAN CARBONATE ROCKS. Bassett, J.L.; Hasenmueller, N.R. (Indiana State Dept. of Natural Resources, Indianapolis (USA). Geological Survey). 1979. Contract EY-76-C-05-5204. 16p. Dep. NTIS, PC A02/MF A01.
INDIANA;PETROLEUM DEPOSITS;NATURAL GAS DEPOSITS;MAPS;DEVONIAN PERIOD;BLACK SHALES; CARBONATES

75 (METC/SP--78/6(Vol.1), pp 219-229) COMPARISON OF THE NEW ALBANY SHALE FROM DEEP AND SHALLOW PARTS OF THE ILLINOIS BASIN IN INDIANA. Shaffer, N.R.; Bassett, J.L.; Carr, D.D.; Chen, P.Y.; Hasenmueller, N.R.; Lechler, P.J.; Leininger, R.K. Oct 1978.
From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).
Chemical, physical, and lithologic characteristics of samples from three cores of the New Albany Shale (Devonian-Mississippian) in the eastern part of the Illinois Basin in Indiana have consistent correlations with electrical resistivity and natural gamma radiation as determined from geophysical logs. Concentration of organic carbon, hydrogen, nitrogen, and vanadium show positive correlations with gamma-ray and resistance values, and carbonate carbon, CaO, MgO, MnO, and Sr show negative correlations in the upper part of the New Albany. In the lower part (Blocher Member), however, CaO, MgO, MnO, and Sr show a positive correlation with resistivity. Sulfur, Zn, FeO (total Fe calculated as FeO), Cr, and Cu distributions also correlate positively with gamma-ray and resistance values; likewise, SiO_2, Al_2O_3, K_2O, Na_2O, and Th, correlate positively but less closely and with major discrepancies. The New Albany in the deep part of the Illinois Basin, represented by the core from Sullivan County, is 125 feet thick and consists mainly of dark-gray to black organic-rich shale. The New Albany in the shallow part of the basin, represented by cores from Marion County, is more than 100 feet thick and has a larger proportion of greenish-gray shale, especially in the Sweetland Creek Member, than the Sullivan County core. Styliolina- and Tentaculites-bearing calcareous organic shale zones at the base and near the top of the basal Blocher Member may be good stratigraphic markers in Indiana. Phosphorous, which is enriched in a thin bed near the top of the New Albany at both sites, may be used to indicate the top of the New Albany where the Rockford Limestone is absent.

76 (METC/SP--78/6(Vol.1), pp 303-309) PRELIMINARY SCANNING ELECTRON MICROSCOPIC STUDY OF ORGANIC MATERIAL IN THE DEVONIAN EASTERN GAS SHALE. Green, D.A.; Lamey, S.C. (Morgantown Energy Technology Center, WV). Oct 1978.
From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).
A scanning electron microscope study on eastern Devonian gas bearing shales was conducted to investigate thermal and chemical effects on the organic distribution and changes within the matrix. Shale samples from Perry County, Kentucky were examined by the scanning electron microscope (SEM) and then subjected to solvent extraction and pyrolysis at 300°C under a nitrogen atmosphere. Changes in the shale as a result of these treatments were analyzed by use of an SEM. Selective removal of portions of the organic material by these techniques was observed. The SEM method, together with chemical and thermal treatment, is potentially useful for determining the distribution of the kerogen and bitumen within the shale.

77 (METC/SP--78/6(Vol.1), pp 360-369) POROUS FRACTURE FACIES IN THE DEVONIAN SHALES OF EASTERN KENTUCKY AND WEST VIRGINIA. Shumaker, R.C. (West Virginia Univ., Morgantown). Oct 1978.
From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).
Preliminary analysis of published fracture data obtained from seven oriented Devonian shale cores taken cooperatively by private industry and the U.S. Department of Energy, Eastern Gas Shales Project shows that fractures are numerous, uniquely oriented, and often mineralized in the highly organic portions of the Devonian shale of eastern Kentucky and West Virginia. These fractures and the commercial gas production generally occur together in the organic shales. The descriptive phrase ''porous fracture facies'' is applied to succinctly label the fractured and productive shale. Inclined slickensided fractures, found in the West Virginia cores, appear to be double shear sets that have an acute angle which open toward the southeast. This orientation is approximately at right angles to the fold axes, which suggests that the fractures developed during the Alleghenian deformation in response to differential shortening across the lower organic shales. A core taken in Kentucky contained horizontal slickinsides in an upper organic shale. Those slickensides trend parallel to the thrust movement of the adjacent Pine Mountain thrust sheet. Inclined slickensided fractures trending North-South are found in a lower organic shale. Many problems remain, and more detailed analysis is being accomplished. The best of several working hypotheses contends that the fracture facie formed within a zone of abnormally high fluid (gas) pressure located primarily in the lower organic shales. The western limit of abnormal high pressure may have been the basement fault zone along the western margin of the Rome Trough. The eastern limit of commercial production and open fractures appears to be the area of more intense tectonic transport in the area of the detached folds and thrusts.

78 (METC/SP--78/6(Vol.1), pp 404-414)
EFFECTS OF PINE MOUNTAIN OVERTHRUST AND OTHER REGIONAL FAULTS ON THE STRATIGRAPHY AND GAS OCCURRENCE OF DEVONIAN SHALES IN KENTUCKY AND VIRGINIA. Zafar, J.S.; Wilson, E.N. (Univ. of Kentucky, Lexington). Oct 1978.
From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).
Geologic characterization of the Devonian-Mississippian shales south and east of the Big Sandy Field in Kentucky is difficult because they thin regionally southwestward, thicken southeastward with approach to a source area, and the whole is distorted by compression and possibly lateral movement along the regional overthrusts of Pine Mountain and the Valley-and-Ridge province. A stratigraphic cross-section from the Appalachian Plateau to the Greendale Syncline illustrates the distortions. The similarity of stratigraphy across the Pine Mountain Fault indicates that the shear surface is in the Upper Huron Unit or above. Further southeast, the replacement of the Cleveland, Chagrin, and Upper Huron equivalents by siltstones and silty shales suggests possible crustal shortening or decollement. A gray shale just above the Lower Huron has been traced nearly across the section as a correlatable unit. The stratigraphy of the substrates of the Shales has been affected by tectonism, but the influence, if any, of this tectonism on the stratigraphy of the Shales is very obscure. In the cored well in Wise County, profuse gas bleeding from the Cleveland and Lower Huron low-density shales is reported, whereas only light bleeding of gas from the less carbonaceous higher-density Middle Huron equivalents are reported.

79 (METC/SP--78/6(Vol.1), pp 444-454)
STRATIGRAPHIC RELATIONSHIPS OF THE NEW ALBANY SHALE GROUP (DEVONIAN--MISSISSIPPIAN) IN ILLINOIS. Reinbold, M.L. (Illinois State Univ., Urbana). Oct 1978.
From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).
The New Albany Shale Group and closely related, adjacent strata in the Illinois Basin can be classed into five main lithologies: black or brownish black shale; gray to greenish gray shale; calcareous or dolomitic shale; siltstone; and limestone. Detailed stratigraphic correlations based on cores, geophysical logs, and sample studies indicate that these lithologies grade vertically and laterally into one another, with complex interfonguing relationships. In this report, these relationships are illustrated by a long northwest-southeast cross section. Facies distribution of the New Albany suggests that these strata were deposited in a stratified anoxic basin. Black shales, which reflect anoxic conditions, predominate near the center of the basin; these shales probably represent the deepest water environments. Olive, gray, and greenish gray shales predominate in basin flank areas; these lithologies indicate low to moderate oxygenation and probably shallower water environments. Limestones, which are thickest in marginal areas of the basin, probably were deposited in shallow, well-oxygenated water.

80 (METC/SP--78/6(Vol.1), pp 370-376)
IMPLICATION OF SPECIFIC DEGASIBILITY FOR MODELS OF GAS PRODUCTION FROM SHALE. Schettler, P.D. Jr. (Juniata College, Huntingdon, PA). Oct 1978.
From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).
Estimations of the potential of Devonian shales for gas production depends upon an accurate model. Wrong models give wrong results; specifically the current crop of wrong models underestimates the productivity of the reservoir by factors of 1000 or more. Two bad conceptualizations include, first, the use of open porosity for estimation of gas content and, second, the use of Darcy's law models applied to the shale fracture system that do not specifically take account of diffusion of gas into the fractures through its walls. Both of these models neglect primary processes involved in shale well production and as such greatly underestimate the capacity of these wells to produce.

81 (METC/SP--78/6(Vol.1), pp 280-290)
APPRAISAL OF KNOWN ANTRIM SHALE AND BEREA OIL AND GAS POOLS IN MICHIGAN. Ells, G.D. (Michigan Dept. of Natural Resources, Lansing). Oct 1978.
From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).
The bituminous and combustible nature of lower Antrim black shales in the Michigan Basin has been known for over 100 years. Antrim Shale gas has been produced for many years, and analyses of its potential oil content were published more than 60 years ago. Now a program is underway to test the feasibility of in situ processing of Michigan's Antrim Shale to produce energy values. Important tasks associated with the total program have involved the construction of geologic cross sections and an appraisal of known oil and gas pools whose reservoirs are within rocks of the black shale sequence. The black shale sequence involves rocks of Upper Devonian and Lower Mississippian age, and includes the Antrim Shale, Ellsworth Shale, Bedford Shale, Berea Sandstone and Sunbury Shale. Stratigraphic cross sections constructed from gamma ray logs show the complicated relationship of these formations in an east to west direction across the Basin. Antrim gas pools are found in several areas of the Basin. Oil and gas pools are also found in the Berea Sandstone of eastern Michigan and in the Ellsworth Shale, a western facies involving the upper part of the Antrim, Bedford, Berea and Sunbury formations of eastern Michigan. A map shows the location of pools discovered to date. Oil and gas pools, cumulative production and other pertinent data are tabulated.

82 (METC/SP--78/6(Vol.1), pp 39-53)
PETROGRAPHIC CHARACTERISTICS FOR DISTINGUISHING GAS-PRODUCTIVE DEVONIAN SHALE FROM NON-PRODUCTIVE SHALE. Nuhfer, E.B.; Vinopal, R.J. (West Virginia Geological and Economic Survey, Morgantown). Oct 1978.
From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).
Complete petrographic data have now been obtained on over 200 samples from the 1250 foot core taken from CGTC Well 20403 from Lincoln County, West Virginia. Comparisons of productive lower Huron-type shales (finely laminated) with non-productive Java formation-type shales (non-banded) reveal significant differences in the textural characteristics of productive versus non-productive shales respectively: (1) abundant fine laminae vs. paucity of fine laminae; (2) lack of bioturbation vs. abundant bioturbation; (3) occurrence of pyrite as very abundant silt and sand sized particles commonly disseminated but also commonly concentrated in or oriented parallel to the laminae vs. coarser sized pyrite aggregates which are almost always oriented randomly with respect to the laminae and do not concentrate to produce a linear fabric; (4) silt sized quartz grains which tend

to concentrate in thin discontinuous wispy laminae vs. silt grains which tend to be isolated and disseminated through the matrix; (5) abundant organic material which is very fine and generally well distributed through the matrix vs. less abundant organic material much of which is commonly seen as discrete particles with discernible structure; and (6) lack of concretions and nodules vs. abundant concretions and nodules of siderite, calcite and barite. It appears that the consistently better productive character of the lower Huron in southwestern West Virginia is mainly the result of the fabric of the finely laminated shale type which promotes better lateral connection of the pore space available than does the more randomly oriented fabric of banded and non-banded shale types. The finely-laminated shale type does occur in subordinate amounts in stratigraphic intervals outside the lower Huron and probably accounts for a number of gas ''shows'' in addition to those caused by fractures which communicate with the lower Huron and intersect the borehole outside that member.

83 (METC/SP--78/6(Vol.1), pp 99-128)
THICKNESS, EXTENT OF AND GAS OCCURRENCES IN UPPER AND MIDDLE DEVONIAN BLACK SHALES OF NEW YORK. Van Tyne, A.M.; Peterson, J.C. (New York State Geological Survey, Alfred). Oct 1978.

From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).

Black shales long known for gas production and shows are found in the Middle Devonian Hamilton and Upper Devonian Genesee, Sonyea, West Falls, and Canadaway Groups in New York. These shales are found to be correlative with units of similar age located to the west and south in surrounding states. Numerous gas shows from black shale sections as well as known black shale gas fields have been cataloged. These indicate a widely dispersed area of possible gas production. A general stratigraphic deepening of production from west to east is indicated. Massive black shales found in the Upper Devonian are thickest in the far western part of New York and become interbedded with silty shales in an eastward direction. Middle Devonian massive black shales are thickest in the east and become thinner and more calcareous to the west. Three facies are represented in the black shale section: Marcellus, distal basin-anaerobic; Portage, open shelf, slope, proximal basin and Chemung, subtidal shelf, nearshore. The Marcellus facies is dominant in the Middle Devonian in central and western New York. In this same area the Upper Devonian rocks were deposited in Marcellus, Portage and Chemung environments. Black, Marcellus facies, shales were progressively overlapped by Portage and Chemung facies of the westward prograding Catskill delta-shelf complex.

84 (METC/SP--78/6(Vol.1), pp 138-148) USE OF INTERNAL SURFACE AREA AND HIGH-PRESSURE METHANE SORPTION DATA TO ESTIMATE CAPACITY FOR GAS PRODUCTION FROM THE NEW ALBANY SHALE GROUP. Frost, R.R.; Thomas, J. Jr. (Illinois State Geological Survey, Urbana). Oct 1978.

From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).

Internal surface areas (ISA) measured via the BET method with N_2 and CO_2 as adsorbates at -196 and -77°C, respectively, were determined on shale samples from Christian County, Kentucky, and from Effingham and Tazewell Counties in Illinois. High-pressure (up to 100 atmospheres) methane sorption isotherms at 28°C were determined for selected shale samples. After the determination of a sorption isotherm, the methane at approximately 100 atmospheres surrounding the shale sample was released to atmospheric pressure, and the release of the sorbed methane with time was then measured at constant pressure (1 atm). Data are presented which show a general direct correlation between the CO_2 ISA, porosity, and the high-pressure methane sorption capacity of the shale samples. The release rate of the sorbed methane is relatively independent of the methane sorption capacity but shows a general inverse correlation with the CO_2/N_2 ISA ratio. Thus, the CO_2/N_2 ISA ratio is a useful indicator of the amount of fracturing (natural or induced) necessary in a shale formation to obtain reasonable rates of gas production.

85 (METC/SP--78/6(Vol.1), pp 161-168)
STRUCTURAL PARAMETERS THAT INFLUENCE DEVONIAN SHALE GAS PRODUCTION IN WEST VIRGINIA AND EASTERN KENTUCKY: A SUMMARY OF PROGRESS FOR 1977--1978. Shumaker, R.C.; de Wys, J.N.; Dixon, J.M.; Kirk, K.G.; Long, B.R.; Nuckols, E.B. III; Rauch, H.W.; Wheeler, R.L.; Wilson, T.H. (West Virginia Univ., Morgantown). Oct 1978.

From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).

Steady progress was made toward obtaining the objective of defining the structural parameters that influence shale gas production. Significant results based on fracture analyses of oriented shale cores show several types of fractures (porous fracture facies) developed in productive zones. Inclined slickensided fractures are different from the fractures which were mapped in overlying surface sediments. In eastern Kentucky the porous fracture facies may have formed by differential tectonic shortening across the shale. Results of a pilot study documenting production characteristics of the Cottageville Field, Jackson County, West Virginia, were reported. Production studies suggest that flexing over a basement structure is also an important mechanism for enhancing fracture porosity. Some thirty-five preliminary regional structure maps at 1:250,000 scale are now complete for the contract area. Field work investigating fractures is underway to define: (1) the vertical and lateral extent of the fracture facies, (2) the nature, orientation, and intensity of fractures within surface lineament zones, and (3) the extent of late stage open fractures in Appalachian folds. A comprehensive study of the Eastern Kentucky Gas Field was initiated. Initial field testing of a shallow high-frequency seismic system in sedimentary terrain defined a near surface fracture zone. Further study in an area of known faulting and in the Cottageville area should provide more definitive testing of the system's capability to directly detect subsurface fracture zone. The groundwater program established relationships between low altitude photo lineaments water production and shale gas production in the Cottageville Field area.

86 (METC/SP--78/6(Vol.2), pp 15-45)
CHARACTERIZATION AND RESOURCE ASSESSMENT OF THE DEVONIAN SHALES IN THE APPALACHIAN AND ILLINOIS BASIN. Zielinski, R.E.; Nance, S.W.; Seabaugh, P.W.; Larson, R.J. (Monsanto Research Corp., Miamisburg, OH). Oct 1978.

From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).

Cored shale samples from five Illinois Basin wells and six Appalachian Basin wells have provided data for biostratigraphic studies and geochemical analyses. Fuel yields were determined using organic carbon content, core

gas analyses, and pyrolysis yields. There are rapid alterations from rich to lean shale in many of the wells. Geochemical studies indicate that the gas is not uniformly distributed but primarily sourced and retained in thin organic-rich zones. Biofacies studies suggest these zones were deposited in a restricted marine environment. The Illinois Basin shales are organically rich; the organic material is primarily composed of algal, amorphous, and herbaceous material. These shales have a significant hydrocarbon producing potential. The characteristics of the Appalachian Basin shales vary regionally. The content of non-marine (woody, coaly) organic debris increases in a southerly direction. The VA-1 shales were almost entirely deposited within a nonmarine environment. The Appalachian Basin shales are less rich in organic material than the Illinois Basin shales. The Appalachian Basin shales are at the initial stages of thermal maturation required for significant hydrocarbon generation. Inorganic geochemical analyses results suggest relationships between the organic carbon content and elemental distribution of the shales. The shale organic carbon content was compared to the concentration of uranium and the ratios of uranium/thorium, vanadium/nickel, and uranium: thorium/vanadium:nickel. The illite concentration generally exceeds 50% of the clay minerals. Chlorite, kaolinite, and quartz are the dominant secondary minerals.

87 (METC/SP--78/6(Vol.2), pp 123-149) SOME THEORETICAL AND EXPERIMENTAL CONSIDERATIONS OF THE HYDRAULIC FRACTURING PROCESS AND SUPPORTING RESEARCH. Hanson, M.E.; Anderson, G.D.; Shaffer, R.J.; Emerson, D.O.; Heard, H.C.; Hairson, B.C. (Univ. of California, Livermore). Oct 1978.

From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).

Theoretical analyses with newly developed two-dimensional numerical models which include complete descriptions of the elastic continuum and porous flow fields have been applied to analyze the effects of pore pressure on the Mode 1 stress concentration factor. These analyses indicate that as the fluid migrates from the fracture into the surrounding medium the stress concentration factor decreases. Predictions of surface tilt above a vertical hydrofracture and a horizontal layer are made for several cases. These cases correspond to (1) varying the elastic parameters in the layer and the surrounding medium and (2) differing layer width and position relative to the hydrofracture. Two general layer configurations are studied: one layer position is above the hydrofracture; the other contains the hydrofracture. Both the layer geometry and the elastic constants affected surface tilt and the local strain field. The mechanical properties of the interface relative to the properties of the materals on either side are important. Mechanical properties measurements of the Devonian shale have been completed with shale cores from Columbia gas well No. 20403. These measurements include tensile strength, failure envelope under pressure, loading moduli, loading path (up to the failure envelope), pressure volume behavior, and dynamic elastic moduli as a function of pressure. There does not appear to be any discernable trend in tensile strength with either depth or between rock units. Furthermore, the tensile strength parallel to bedding seems to be about two times that measured normal to bedding. For compressional waves, the anisotropy decreases with increasing pressure. 26 figures, 2 tables.

88 (METC/SP--79/6, pp 63-78) PETROLOGIC EVALUATION OF THE SIGNIFICANCE OF NATURAL FRACTURES IN LOW-POROSITY SHALE GAS RESERVOIRS: RESULTS OF INVESTIGATION IN THE UPPER DEVONIAN OF VIRGINIA AND WEST VIRGINIA. Vinopal, R.J.; Nuhfer, E.B.; Klanderman, D.S. (West Virginia Geological and Economic Survey, Morgantown). 1979.

From 3. Eastern gas shales symposium; Morgantown, WV, USA (1 Oct 1979).

Economic production of gas from the Devonian shales of the Appalachian Basin is dependent on the presence of natural or induced fracturing. Investigation of natural fractures in five cored wells of varying productivity indicates that fracture frequency alone is not the sole control of well productivity. A one to one relationship between natural fracture seen in cores and gas shows indicated by temperature and sibilation logs is not present. This is attributed to degrees of permeability enhancement by different fracture types. No system of abundant microfractures was documented after study of nearly 400 shale samples by radiography, thin section, and SEM. Thus, only macroscopic fractures are of importance. Horizontal to subvertical slickensided fractures, even with frequencies of 2 to 3 per foot, are not associated with gas shows in organic-rich, laminated shales. Examination of their surfaces by SEM shows complete obliteration of grain to grain boundaries and a uniform, glassy surface of low permeability. High angle vertical fractures, associated with higher gas productivity, retain some openness and permeability in the subsurface due to mineralization and slight movement between fracture hackles. The most productive well, final open flow of 1007 MCFPD, possessed high angle vertical fractures in its pay zone of organic-rich laminated shale. Slight offsetting along fracture hackles opened widths up to 28mm. Vertical fractures with no mineralization, indication of offsetting along hackles or gas shows, are interpreted as being closed at depth. 10 figures.

89 (METC/SP--79/6, pp 85-114) PETROLOGY AND MATURATION OF DISPERSED ORGANIC MATTER IN THE NEW ALBANY SHALE GROUP OF THE ILLINOIS BASIN. Barrows, M.H.; Cluff, R.M.; Harvey, R.D. (Illinois State Geological Survey, Urbana). 1979.

From 3. Eastern gas shales symposium; Morgantown, WV, USA (1 Oct 1979).

The New Albany Shale Group of the Illinois Basin is being studied to evaluate its potential for yielding hydrocarbons. Coal petrographic techniques were employed to evaluate the composition and thermal maturity of dispersed organic matter in the shales. Vitrinite reflectance was measured on acid-macerated kerogen separates from 11 cores and 126 cuttings from drill holes through the New Albany Shale in Illinois, Indiana, and western Kentucky. No significant variations in reflectance values were observed within the New Albany any any single location with respect to either depositional facies or depth. An isoreflectance map prepared from the data shows large areas of the Illinois Basin where reflectance is uniformly low (< 0.5% anti R_o) and the organic matter has not yet reached the stage of petroleum generation. Several areas of higher reflectance are also present: (1) near the northern erosional truncation of the New Albany in central Illinois; (2) in east-central Illinois, within a broad southward plunging syncline immediately west of the Clay City Anticlinal Belt; (3) in Wayne and Hamilton Counties, Illinois, the present-day area of maximum burial depth; and (4) in extreme southeastern Illinois, where the highest

reflectances yet observed (> 1.0% anti R_o) correspond to a complexly faulted and mineralized area with nearby igneous intrusions. Changes in color and intensity of uv fluorescence of liptinites are generally in good agreement with reflectance data. Occurrence and abundance of amorphous organic matter, alginites (mainly Tasmanites), vitrinites, and exinites are facies dependent. Solid hydrocarbons that occur as pore fillings in fusinite are found mainly in samples from southeastern Illinois. Their presence suggests that hydrocarbon generation and expulsion have occurred in the New Albany in southeastern Illinois. 23 figures.

90 (METC/SP--79/6, pp 165-209) INORGANIC GEOCHEMISTRY STUDIES OF THE EASTERN KENTUCKY GAS FIELD. Negus-de Wys, J.; Renton, J.J. (West Virginia Univ., Morgantown). 1979.
From 3. Eastern gas shales symposium; Morgantown, WV, USA (1 Oct 1979).
The Upper Devonian Ohio Shale sequence including the Cleveland, Three Lick, and Upper, Middle, and Lower Huron, and the Mississippian Berea-Bedford sequence are studied by using XRF and XRD on > 500 samples from 14 wells from the Eastern Kentucky Gas Field. Elements studied are Mg, Al, Si, P, K, Ca, Ti, Mn, Fe, S, Cu, Zn, Sr, and Na. Minerals included in the study are chlorite, illite, kaolinite, anhydrite, szomolnokite ($FeSO_4 \cdot H_2O$), quartz, orthoclase, plagioclase, calcite, dolomite, siderite, pyrite, and bassanite ($CaSO_4 \cdot 1/2\ H_2O$). Ratios studied were Si/Al and five mineralic ratios: (1) kaolinite/kaolinite + illite; (2) quartz/quartz + kaolinite + illite + chlorite; (3) siderite/calcite + dolomite + siderite; (4) calcite/calcite + dolomite; and (5) chlorite/chlorite + kaolinite. The data are examined in terms of average values for total producing sequence, for Ohio Shale sequence and for each stratigraphic unit. Computer-drawn maps, using six contour levels, are compared with final open flow data patterns from a hand-contour map using approx. 4750 data points and with maps showing density contours of high-producing wells. A striking pattern match is shown by several elemental maps with the high-producing well density maps. The mineralic ratios run are perhaps best used as paleoenvironmental indicators and interpreters of the elemental complexes. Changes of given elements and minerals, within and between wells, are shown for comparison across the Eastern Kentucky Gas Field. The pattern relationships are not obvious from the graphs, nor are they from the formation density logs of the wells. 39 figures.

91 (METC/SP--79/6, pp 511-525) DISTRIBUTION AND GEOCHEMICAL CHARACTERIZATION OF THE HANNIBAL MEMBER OF THE NEW ALBANY SHALE IN INDIANA. Lechler, P.J.; Hasenmueller, N.R.; Bassett, J.L.; Leininger, R.K. (Indiana Geological Survey, Bloomington). 1979.
From 3. Eastern gas shales symposium; Morgantown, WV, USA (1 Oct 1979).
The Hannibal Member, the uppermost unit of the New Albany Shale (Mississippian-Devonian) in the subsurface of the Illinois Basin in Indiana, has been correlated with the Jacobs Chapel, Henryville, Underwood, and Falling Run Beds (in descending order) of the southeastern Indiana outcrop area. The stratigraphic completeness of the Hannibal Member and its outcrop equivalents is geographically variable. The Hannibal is overlain by the Rockford Limestone (Lower and Middle Mississippian) or by the New Providence Shale (Middle Mississippian) and is underlain by the brownish-black shale of the Clegg Creek Member (equivalent to the upper part of the Grassy Creek Shale of Illinois) of the New Albany Shale. The Mississippian-Devonian boundary has been placed at or slightly below the base of the Falling Run Bed. The Jacobs Chapel is greenish-gray glauconitic shale. The Henryville is black organic-rich shale that has the highest organic carbon content of all units of the New Albany sections and is strongly enriched in heavy metals. The Underwood is greenish-gray shale that is irregularly distributed and various greatly in thickness. The Falling Run is a bed of nodular phosphate or phosphatic debris high in Ca, P, F, Y, and U. The geochemistry of the Hannibal Member and of its outcrop equivalents is significantly different from that of the underlying members (Devonian) of the New Albany Shale. Statistical analysis shows the Hannibal to be significantly enriched in many trace elements relative to the underlying New Albany members and to many other black shales of North America. 7 figures, 5 tables.

92 (METC/SP--79/6, pp 527-542) ACOUSTIC AND MECHANIC ANALYSIS OF A TRANSVERSE ANISOTROPY IN SHALE. Miller, D.D.; Johnson, R.J.E. (Illinois State Geological Survey, Urbana). 1979.
From 3. Eastern gas shales symposium; Morgantown, WV, USA (1 Oct 1979).
A transverse anisotropy perpendicular to the bedding planar anisotropy characterizes the mechanical behavior of the New Albany Shale (Devonian-Mississippian) in the structurally faulted area of Christian County, Kentucky. A set of vertical fractures and microfractures in the rock apparently controls the directional behavior of the rock during destructive laboratory tests. A series of tests showed that nondestructive acoustic velocity determinations are unable to consistently detect the anisotropy identified by destructive testing and visual and microscopic examination of the shale. The inability of acoustic velocity testing to detect the known fracture trend and orientation of transverse weakness is thought to be due to the tight, discontinuous nature of microfractures, and mineralization present in some microfractures. 8 figures.

93 (METC/SP--79/6, pp 211-223) PYROLYSIS OF EASTERN GAS SHALE-EFFECTS OF TEMPERATURE AND ATMOSPHERE ON THE PRODUCTION OF LIGHT HYDROCARBONS. Chou, M.I.M.; Dickerson, D.R. (Illinois State Geological Survey, Urbana). 1979.
From 3. Eastern gas shales symposium; Morgantown, WV, USA (1 Oct 1979).
Samples of black shales from four cores of the New Albany Shale Group (Devonian-Mississippian) from the Illinois Basin in Kentucky and Illinois were used in this study. Sections 4 inches long were taken from 4-inch diameter cores and were sealed in canisters for study of released gas. Following study of released gas, the shale was crushed to < 100 mesh for use in the study of the effects of temperature and atmosphere on pyrolysis of shale. The correlation coefficients between the quantity of gas released at room temperature from the canistered core sections and the organic carbon content, and between the gas released and the total porosity of the shale samples were calculated for the individual cores. A study was made of the gaseous hydrocarbons produced by pyrolysis of shale at 600°C. Two regression lines could be drawn on the graph of the hydrocarbon gas produced versus the original organic carbon content, one ($r^2 = 0.96$) fitting data points for the Illinois cores and the other ($r^2 = 0.92$)

fitting data points for the Kentucky core. The formation of alkanes was favored over that of alkenes, particularly at low temperature. Methane, ethane, and ethylene from thermal cracking and higher carbon number alkenes were positively identified in the gases from shale heated to above 120°C. A study was made of the effect of the pyrolysis atmosphere on the yield of light hydrocarbons (C_1 to C_8), carbon dioxide, carbon monoxide, acetaldehyde, and acetone during thermal degradation of a gram amount of selected shale samples. The yield of an individual hydrocarbon generally increased with the increase in the oxygen content of the pyrolysis atmosphere until the oxygen content reached the 10% level. The yield of carbon dioxide and carbon monoxide increased with the increase in oxygen content of the pyrolysis atmosphere.

S4 (MLM--2563) GEOCHEMICAL EVALUATION OF THE EASTERN GAS SHALES. PART I. McIver, R.D.; Zielinski, R.E. (Mound Lab., Miamisburg, OH (USA)). 29 Sep 1978. Contract EY-76-C-04-0053. 35p. Dep. NTIS, PC A03/MF A01.

Work devoted to assessment of Eastern gas shales is reported. It is noted that although the Late Devonian-age dark shales of the Eastern Interior Basins are thought to be uniformly gassy, organic geochemical studies in the Appalachian and Illinois Basins show that the gas is not uniformly distributed and that most of the gas is probably sourced and largely retained in thin, organic-rich zones that were deposited in restricted marine environments. As the Devonian-age basins filled, the environments of deposition of the Appalachian Basin and Illinois Basin became nonmarine more and more northerly and northwestwardly, respectively. Heavy hydrocarbon-to-organic carbon ratios show that the organic matter associated with the restricted marine environments is different in the two basins. During virtually the entire period in question, the Appalachian Basin had a direct connection; the Illinois Basin was somewhat isolated by the already developing Cincinnati Arch on the east and the Kankakee or Wabash Arch on the north. However, the differences in organic matter noted in this study suggest a northwest connection of the Illinois Basin to a different ocean mass than that which supplied marine waters to the Appalachian Basin. As a fossil fuel resource, certain facies within the dark Devonian-age shale are much richer gas sources than others. The most prolific potential reservoirs (naturally occurring or induced) should be sought or located in the geologic section containing orcontiguous to the richest organic source intervals; i.e., rocks deposited in restricted marine environments. The amount of gas in rocks of each interval depends directly on the amount of detrital organic matter. Virtually all the gas as well as virtually all the liquid hydrocarbons are retained in the rock where they were generated.

S5 (MLM--2651(OP)) CURRENT ASSESSMENT OF THE PHYSIOCHEMICAL CHARACTERIZATION DATA FOR THE EASTERN GAS SHALES. Nance, S.W.; Zielinski, R.E. (Mound Facility, Miamisburg, OH (USA)). 1979. Contract EY-76-C-04-0053. 25p. Dep. NTIS, PC A02/MF A01.

Physiochemical characteristics were evaluated for over 700 core and drill cutting samples from Upper Devonian Gas Shales. These samples were selected from seven Illinois Basin and fourteen Appalachian Basin wells. The organic carbon content, thermal maturation and organic matter type primarily determine the gas potential of these shales. The average organic carbon content of Devonian shales is consistently greater than the minimum content required for clastic source rocks to generate a significant volume of hydrocarbons. The potential gas yield of shales predominantly containing propelic (marine sourced) material is significantly greater than for those predominantly containing humic (non-marine) material. In general, Illinois Basin shales are organically rich and contain varying proportions of terrestrial versus marine sourced organic matter. However, these shales are too thermally immature to have generated significant hydrocarbons. An exception to this trend occurs in the southern regions of this basin (Hardin County, Illinois) where the shales are primarily composed of terrestrially derived, organic matter and are more thermally mature. The organic matter of the Appalachian Basin shales trend from a very mature, terrestrially derived, organically leaner type in the regions east of the basin axis to a less mature, mixed marine/non-marine, organically richer type in the western regions. The Upper Devonian interval of this latter region contains gases with a higher gas-producing potential and Btu values. The primary source of these wet gases is within shale intervals associated with an organically and algal-rich (restricted marine) facies. Determining shale hydrocarbon gas or organic carbon content by current methods of log analysis appears to be of limited effectiveness. However, alternative methods of remote sensing have the potential to improve the determination of these key reservoir parameters.

96 (ORO--5194-2(Vol.2)) ANALYSIS OF THE STRUCTURAL PARAMETERS THAT INFLUENCE GAS PRODUCTION FROM THE DEVONIAN SHALE. ANNUAL PROGRESS REPORT. VOLUME 2. DATA REPOSITORY AND REPORTS PUBLISHED DURING FISCAL YEAR 1977-1978. Shumaker, R.C.; Negus de Wys, J.; Dixon, J.M. (West Virginia Univ., Morgantown (USA). Dept. of Geology and Geography). Oct 1978. Contract EY-76-C-05-5194. 237p. Dep. NTIS, PC A11/MF A01.

Six appendices are included in this report: regional structure data, surface structure data, surface fracture data, production data, hydrology data, and geophysical data. (DLC)

97 (ORO--5197-10) STUDY OF HYDROCARBON-SHALE INTERACTION. PROGRESS REPORT NO. 10, JULY 1--SEPTEMBER 30, 1978. Schettler, P.D. Jr. (Juniata Coll., Huntingdon, PA (USA)). 1978. Contract EY-76-S-05-5197. 74p. Dep. NTIS, PC A04/MF A01.

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Work during the report period was directed at obtaining data at the maximum design equipment rate (1-2 samples/day). Procedures were streamlined so as to be able to approach the equipmental design rate during the academic year. Work on the high pressure apparatus was delayed because of delays in delivery of component parts. Data on diffusion, degassing, isotherm, and BET parameters of particulate core samples from gas wells in Ohio, West Virginia, Illinois, and Kentucky are tabulated. (JRD)

98 (ORO--5197-10(Pt.2)) STUDY OF HYDROCARBON-SHALE INTERACTION. PROGRESS REPORT NO. 10. PART II. APPENDIX B. (Juniata Coll., Huntingdon, PA (USA)). 1978. Contract EY-76-S-05-5197. 87p. Dep. NTIS, PC A05/MF A01.

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The volume represents a continuation of Appendix B in which data are presented on

diffusion, degassing, isotherm, and BET parameters of particulate core samples from gas wells in Ohio, West Virginia, Illinois, and Kentucky. (JRD)

99 (ORO--5197-10(Pt.3)) STUDY OF HYDROCARBON-SHALE INTERACTION. PROGRESS REPORT NO. 10. PART III. APPENDIX B. (Juniata Coll., Huntingdon, PA (USA)). 1978. Contract EY-76-S-05-5197. 78p. Dep. NTIS, MF A01.
Portions of document are illegible.
The volume represents a continuation of Appendix B in which data are presented on diffusion, degassing, isotherm, and BET parameters of particulate core samples from gas wells in Ohio, West Virginia, Illinois, and Kentucky. (JRD)

100 (ORO--5198-T3) DOE EASTERN GAS SHALE PROJECT. QUARTERLY REPORT OF TECHNICAL PROGRESS, JANUARY--MARCH, 1979. Harper, J.A.; Abel, K.D.; Piotrowski, R.G. (Pennsylvania Dept. of Environmental Resources, Harrisburg (USA). Bureau of Topographic and Geologic Survey). 1979. Contract EY-76-S-05-5198. 2p. Dep. NTIS, PC A02/MF A01.
All project tasks have been fulfilled. All deliverable items have been sent to DOE, Morgantown, WV. Delays in drafting of maps and cross sections were due to lack of drafting formats from DOE. Delays in printing of the cross sections were due to their large size. Future work will be conducted under Contract DE-AS21-76MC05198 (Modification No. M003).

101 (ORO--5198-T5) DOE EASTERN GAS SHALE PROJECT: DUNKIRK STUDY. QUARTERLY REPORT OF TECHNICAL PROGRESS, JANUARY--MARCH, 1979. Harper, J.A.; Abel, K.D.; Piotrowski, R.G. (Pennsylvania Dept. of Environmental Resources, Harrisburg (USA). Bureau of Topographic and Geologic Survey). 1979. Contract AS21-76MC05198. 3p. Dep. NTIS, PC A02/MF A01.
This is the first report of work under contract No. DE-AS21-76MC05198 (Modification No. M003). Ten cross sections have been completed and are presently being drafted. These cross sections were used as the basis with which all other logs in the study area were correlated. The 228 logs were used and the data has been collected from them. So far three isopach, 2 structure contour, and 2 lithofacies maps have been completed and are awaiting drafting. A production and show map has also been completed and is awaiting drafting. So far, all work is on schedule. Encoding of data will begin in June with the arrival of several summer geologic aides.

102 (ORO--5201-4) ANNUAL AND FOURTH QUARTER REPORT FOR 1977--1978. Potter, P.E.; Maynard, J.B.; Pryor, W.A. (Cincinnati Univ., OH (USA)). 1 Oct 1978. Contract EY-76-C-05-5201. 27p. Dep. NTIS, PC A03/MF A01.
Studies of shales in the Appalachian area are reported (mainly in the form of abstracts of reports or manuscripts). They discuss the geology, lithology, stratigraphy, radioactivity, organic matter, the isotopic abundance of carbon and sulfur isotopes, etc. of shales in this area with maps. One report discusses Devonian paliocurrents in the central and northern Appalachian basin. Another discusses sedimentology of the Brallier Formation. The stratigraphy of upper Devonian shales along the southern shore of Lake Erie was also studied. (LTN)

103 (ORO--5202-2) BLACK SHALE STUDIES IN KENTUCKY. QUARTERLY REPORT. (Kentucky Univ., Lexington (USA); Kentucky Geological Survey, Lexington (USA)). Sep 1978. Contract EY-76-C-05-5202. 25p. Dep. NTIS, PC A02/MF A01.
Work during the quarter was devoted to final interpretation, integration, and compilation of surface stratigraphic and petrologic data into deliverable documents for DOE, MERC. As of September, two such documents have been prepared. A thesis on black-shale outcrop stratigraphy from the two eastern Kentucky outcrop belts has been completed and will be included with the annual report and a thesis on the thin-section petrology of three eastern Kentucky cores has also been completed and will be included with the annual report. Also during this quarter the transition to two new parts of the project was started including map compilation and a paleontological--paleoecological study. Compilation of isopach, lithofacies, and structural contour maps depends largely on completion of the well-log inventory from which all the data are generated. At present, well-log inventories for 37 of the 41 eastern Kentucky counties (90%) have been completed. Work has begun, however, on compiling data from the completed county inventories. Work has also begun on the paleontological--paleoecological portion of the project. A research assistant has been found to complete a thesis study on this part of the project and he is currently engaged in preliminary research.

104 (ORO--5203-T1) GEOLOGIC AND GEOCHEMICAL STUDIES OF THE NEW ALBANY GROUP (DEVONIAN BLACK SHALE) IN ILLINOIS TO EVALUATE ITS CHARACTERISTICS AS A SOURCE OF HYDROCARBONS. QUARTERLY PROGRESS REPORT, OCTOBER 1-DECEMBER 31, 1978. Bergstrom, R.E.; Shimp, N.F. (Illinois State Geological Survey, Urbana (USA)). 1 Jan 1979. Contract EY-76-C-05-5203. 55p. Dep. NTIS, PC A04/MF A01.
This proect is a detailed analysis of the lithology, stratiraphy, and structure of the New Albany Group in Illinois to determine those characteristics of lithology, thickness, regional distribution, vertical andlateral variability, and deformation that are most relevant to the occurrence of hydrocarbons.

105 (ORO--5205-11-1) CHARACTERIZATION AND ANALYSIS OF DEVONIAN SHALES AS RELATED TO RELEASE OF GASEOUS HYDROCARBONS. WELL V-7 WETZEL COUNTY, WEST VIRGINIA. Kalyoncu, R.S.; Boyer, J.P.; Snyder, M.J. (Battelle Columbus Labs., OH (USA)). 15 Aug 1979. Contract EY-76-C-05-5205. 133p. Dep. NTIS, PC A07/MF A01.
This program was initiated in September 1976, with the objective and scope of determining the relationships between the shale characteristics, hydrocarbon gas contents, and well location, and thereby provide a sound basis for (1) assessing the productive capacity of the Eastern Devonian Gas Shale deposits, and (2) guiding research, development and demonstration projects to enhance the recovery of natural gas from the shale deposits. Included in the scope of the program are a number of elemental tasks as a part of the Resource Inventory and Shale Characterization subprojects of DOE's Eastern Gas Shales Project designed to provide large quantities of support data for current and possibly future needs of the Project.

106 (ORO--5205-11-2) CHARACTERIZATION AND ANALYSIS OF DEVONIAN SHALES AS RELATED TO

RELEASE OF GASEOUS HYDROCARBONS. WELL K-4 JOHNSON COUNTY, KENTUCKY. Kalyoncu, R.S.; Snyder, M.J. (Battelle Columbus Labs., OH (USA)). 15 Aug 1979. Contract EY-76-C-05-5205. 158p. Dep. NTIS, PC A08/MF A01.

Various characterization tasks were performed on 54 cored shale samples from Johnson County, Kentucky. Core samples were obtained from depths of 967 to 1510 feet. A total of 126 samples were canned for several DOE contractors, including Battelle Columbus. Free gas analyses indicate the presence of significant quantities of higher chain hydrocarbon gases in the K-4 shales. Hydrocarbon gas release rates and kinetic studies indicate that diffusion coefficients are inversely proportional to the square root of the molecular weight of diffusing species. Although wide scatter is observed in the chemical and physical characterization data, good correlations exist between the hydrocarbon gas contents and various laboratory characterization values (physical and chemical). A number of one-to-one relationships are pointed out and discussed. Lithologically, inorganic portions of K-4 shales are composed predominantly of quartz and illite with small quantities of pyrite and various carbonate minerals.

107 (ORO--5205-T6) CHARACTERIZATION AND ANALYSIS OF DEVONIAN SHALES AS RELATED TO RELEASE OF GASEOUS HYDROCARBONS. WELL N-4 HARDIN COUNTY, ILLINOIS. Kalyoncu, R.S.; Snyder, M.J. (Battelle Columbus Labs., OH (USA)). 24 Sep 1979. Contract EY-76-C-05-5205. 31p. Dep. NTIS, PC A03/MF A01.

Comprehensive characterization work was performed on shales from Hardin County, Illinois (N-4). A total of 39 samples (19 for Battelle and 20 for other DOE contractors) were collected from this site. N-4 shales are basically characterized by complete absence of hydrocarbon gases and rather low organics (C-H) contents. In the absence of hydrocarbon gases, no meaningful correlations could be observed between the characterization data and potential productive capacity of the well.

DRILLING, FRACTURING, AND MINING

108 (DOE/LC/01791--T1) OIL SHALE IN SITU RESEARCH AND DEVELOPMENT. FINAL REPORT, AUGUST 1, 1977--DECEMBER 22, 1978. Jensen, H.B. (Talley Energy Systems, Inc., Scottsdale, AZ (USA)). 1978. Contract AC20-79LC01791. 238p. Dep. NTIS, PC A11/MF A01.

The selected Site Section 17 was prepared for hydraulic fracturing and explosive rubblization, and these operations accomplished. This report presents the field and laboratory preparations for the fracturing, rubblization, and evaluation operations. A series of four, parallel, hydraulically induced fractures was created during the first year. The evaluation tests showed the following about the four hydraulic fractures: (1) They were horizontal and narrow, that is, as large as 0.05 inches thick within a 50-foot radius and as small as 0.0011 inches thick for the average of all four fractures over the entire radius. (2) They extended at least 113 feet to the outer ring of production wells in a southeasterly direction. (3) They extended out beyond the outer ring of production wells in a northwesterly direction. (4) They had some degree of communication with the naturally fractured aquifer lying about them. And, (5), they had no significant communication with naturally fractured aquifer lying below them. The rubblization event took place on 21 August 1978, early in the second year of the contract. An evaluation of the areal extent, thickness, porosity, interconnectivity, and the influence of the explosion upon the adjacent aquifers was determined. The dynamic tests showed that the explosive slurry was loaded into the four hydraulic features and that detonation occurred simultaneously. The postrubblization evaluation demonstrated that: (1) There were four layers of damage of less than two-feet thick each, (2) massive permeability was apparent from all production wells, and (3) the permeability is in the form of block, open cracks rather than porous medium.

109 (FE--2343-6(Vol.1)) REVIEW AND ANALYSIS OF OIL SHALE TECHNOLOGIES. VOLUME 1. OIL SHALE DEPOSITS, MINING METHODS, AND ENVIRONMENTAL CONCERNS. Jee, C.K.; White, J.D.; Bhatia, S.K.; Nicholson, D. (Booz-Allen Applied Research, Inc., Bethesda, MD (USA)). Aug 1977. Contract EX-76-C-01-2343. 71p. Dep. NTIS, PC A04/MF A01.

This volume describes and discusses oil shale deposits of the U.S., applicable methods for mining the shale, and the environmental concerns associated with oil shale technologies. Mining is required to supply shale to the retorts of aboveground processes. The majority of oil shale mining is expected to be by the underground room-and-pillar method. Surface mining (i.e., open pit mining) may also be used to supply material for surface retorts and may be appropriate for up to 15 to 20% of the oil shale resources. Principal environmental issues unique to true and modified in situ oil shale processing include disposal of retort water and drill cuttings, migration of fluids during and after in situ processing, surface thermal changes, and hazardous materials that may be leached from spent shale. Other site-specific problems of in situ processing include off-gas emissions, fugitive dust generation, land disturbance, and water usage. The environmental issues are similar for oil shale surface processes, except for surface thermal changes. The degree of impact, however, is expected greater than that for either the true or the modified in situ process.

110 (FE--2346-18) ANTRIM OIL SHALE: BRINE REMOVAL. Evans, D.W. (Dow Chemical Co., Midland, MI (USA). Hydrocarbons and Energy Research Dept.). Aug 1977. Contract EX-76-C-01-2346. 35p. Dep. NTIS, PC A03/MF A01.

Over 63,000 gallons of brine were removed from a ten well system on the front forty acres of Dow's Sanilac County Oil Shale Field Site using airlift and Reda pumps from December 17, 1976, to June 30, 1977. Brine continues to enter the system at 4,000 to 6,000 gallons/month, for the most part in a four well zone highly fractured by explosives. The system will be periodically airlifted or pumped from July until the conclusion of a combustion experiment scheduled from August 1977 to February 1978.

111 (LA--7338-PR) EXPLOSIVELY PRODUCED FRACTURE OF OIL SHALE. PROGRESS REPORT, JANUARY--MARCH 1978. Carter, W.J. (comp.). (Los Alamos Scientific Lab., NM (USA)). Sep 1978. Contract W-7405-ENG-36. 18p. Dep. NTIS, PC A02/MF A01.

Much of the oil shale program effort at the Los Alamos Scientific Laboratory during the past quarter involved preparations for the intermediate-scale field tests that are due to begin in July 1978 at the Colony Mine. Laboratory work in material studies, explosive characterization, and computer predictive

modeling development have therefore proceeded at a slower rate. Considerable effort has been devoted to performing and interpreting flash x-radiographic studies of cavity formation in a spherical geometry. The experimental results are not yet understood, but anisotropic effects seem to play a strong role both in wave propagation and plastic deformation. These studies will continue. Also, computer simulation studies of rubbing caused by different explosives in the same material and geometry have been performed. Although the fracture criterion for rubbing is not sophisticated enough to allow quantitative comparison of rubbing efficiency, the general features of the calculations do allow at least a qualitative comparison and therefore are useful for determining emplacement geometry, timing, and boostering.

112 (LA--7357-PR) EXPLOSIVELY PRODUCED FRACTURE OF OIL SHALE. PROGRESS REPORT, APRIL 1977--MARCH 1978. Carter, W.J. (Los Alamos Scientific Lab., NM (USA)). Nov 1978. Contract W-7405-ENG-36. 113p. Dep. NTIS, PC A06/MF A01.

Characterization of wave propagation parameters for Green River Oil Shale is essentially complete, although much work is needed to define the fracture mechanisms adequately. Several fracture models have been developed and await large-scale verification; these models predict interesting and potentially useful effects arising from anisotropy. The results of material parameter variation and explosive type, boostering, and geometrical emplacement given represent a first step in optimization of the large-scale explosive event designed to create a modified in situ retort. Plans for the LASL/Colony Mine experiments also are presented; these tests are crucial to development of a computer-based, predictive rock mechanics capability.

113 (LA--7438-PR) EXPLOSIVELY PRODUCED FRACTURE OF OIL SHALE. PROGRESS REPORT, APRIL--JUNE 1978. Carter, W.J. (comp.). (Los Alamos Scientific Lab., NM (USA)). Oct 1978. Contract W-7405-ENG-36. 30p. Dep. NTIS, PC A03/MF A01.

Substantial progress in the theoretical description of rock fracture has been achieved during the last quarter. Two approaches are under consideration. The first uses a continuum measure of damage based on a theory of plasticity using a nonassociated flow rule. The second is based on detailed modeling of crack statistics and crack physics and offers the possibility of ab initio prediction of particle size distribution and permeability. This approach is discussed in three sections of this report, presenting the effect of yielding on crack stability, a general theory of statistical crack mechanics, and a special case in which the crack distribution is a combination of an isotropic and a bedded distribution. Both approaches are being programmed for inclusion in the computer hydrodynamic programs, and preliminary calculations have been performed for planning, support, and evaluation of the LASL/Colony oil shale field tests.

114 (LA-UR--79-646) CALCULATION OF EXPLOSIVE ROCK BREAKAGE: OIL SHALE. Johnson, J.N. (Los Alamos Scientific Lab., NM (USA)). 1979. Contract W-7405-ENG-36. 10p. (CONF-790606--1). Dep. NTIS, PC A02/MF A01.

From 20. US symposium on rock mechanics; Austin, TX, USA (3 Jun 1979).

Improved efficiency in explosive rock breakage becomes increasingly important as mining costs and the need to tap underground resources continue to grow. Industry has recognized this need for many years and has done a great deal in developing new products and new blasting techniques, generally by purely empirical means. One particular application that has received added attention within the past several years, and one that lends itself to a more objective theoretical study, is explosive fracture of oil shale for conventional and in situ fossil energy recovery. Numerical calculation of oil shale fracturization with commercial explosives has the potential to add to an objective understanding of the breakage process. Often, in such numerical studies, only one or two parts of the total problem are addressed with any degree of sophistication or completeness. Here an attempt is made to treat the entire problem, i.e., explosive characterization, constitutive behavior of intact rock, and a mathematical description of rock fracture. The final results are two-dimensional calculations of explosively induced fracture damage in oil shale.

115 (MERC/SP--77/5, pp 410-424) ROCK MECHANICS ASPECTS OF MHF DESIGN IN EASTERN DEVONIAN SHALE GAS RESERVOIRS. Jones, A.H.; Abou-Sayed, A.S.; Rogers, L.A. (Terra Tek, Inc., Salt Lake City, UT). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

As part of an ERDA/OGST program, rock mechanics considerations are used to help design deeply penetrating hydraulic fractures in Devonian shale at Columbia Gas System Service Corporation wells in Lincoln County, West Virginia. Rock properties of the pay zone were considered in relation to the barrier formations. Formation properties ... specifically, elastic moduli, critical stress-intensity factor and the minimum in situ stresses ... were determined from laboratory core measurements and field tests. Analyses using formation properties suggest that the Middle Brown Shale zone is the layer (in the Devonian shale) that is most likely to ''contain'' a deeply penetrating hydraulic fracture. Fracture containment analyses indicated that the gray shales on either side of the Middle Brown would act as barriers to fracture growth, provided the fracture fluid is injected at a pressure that does not exceed the naturally occurring stress in the Middle Brown Shale by more than 400 psi. The Lower Brown Shale and the Upper Brown Shale are also preferred zones for fracturing but at less favorable conditions. Fracture fluid injection pressure in the Lower and Upper Brown Shales should exceed the naturally occurring stress in the reservoir rock by no more than 250 psi and 200 psi, respectively. Fracture initiated in the gray shales would be expected to move out of zone. 10 figures.

116 (MERC/SP--77/5, pp 389-409) NOVEL FRACTURING TREATMENTS IN THE DEVONIAN SHALE. Cremean, S.P. (Columbia Gas System Service Corp., Columbus, OH). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

Two programs are being conducted on the technical and economic effectiveness of massive hydraulic fracturing (MHF) and cryogenic fracturing techniques for enhanced gas recovery in the Upper Devonian shales of the eastern United States. Three shale wells to be massively fractured under ERDA contract No. E(46-1)-8014 are located in a 5,000 acre undeveloped tract in western Lincoln County,

West Virginia. In each of the three wells, selected with remote sensing imagery for proximity to surface features (lineaments), the total depth encompasses the entire Upper Devonian shale; a sequence which contains four primary zones of interest. The scope of this investigation is to individually stimulate these twelve zones of interest with various MHF techniques. Since inception, six MHF stimulation treatments have been performed using foam and modified water in two of the wells. The third well is being preserved to utilize information learned from the first two. Four shale wells to be cryogenically fractured under ERDA contract No. EF-76-C-05-5303 are located in Martin County, Kentucky (2 wells), Wise County, Virginia (1 well), and Trumbull County, Ohio (1 well). In the first three wells, selected with remote sensing imagery, the total depth encompasses the entire Upper Devonian shale; a sequence which contains four primary zones of interest in the areas studied. Two zones of interest will be individually fractured using cryogenic fluids in each of these wells. The fourth well was chosen to test the technical and economical feasibility of stimulating the shale in a well currently producing from a deeper horizon. There are four zones of interest in the Devonian shale in this well, of which two will be individually stimulated. None of the shale wells in this program have yet been stimulated. 8 figures, 6 tables.

117 (METC/SP--78/6(Vol.1), pp 377-395)
ADVANCED EXPLOSIVE STIMULATION APPROACH FOR DEVONIAN SHALE. Schott, G.L.; Marsh, S.P.; Mautz, C.W.; Burback, R.L.; Jacobson, J.D.; Carter, W.J. (Los Alamos Scientific Lab., NM). Oct 1978.
From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).
As part of the Eastern Gas Shales Project, the Los Alamos Scientific Laboratory is investigating the application of improved shaped charges lined with uranium metal to the open-hole explosive stimulation of gas in tight, carbonaceous shales. Above-ground testing methods for charges having several pounds of explosive were developed and used to determine optimum thickness of uranium liner in hemispherical charges as a reference design. Tests with encased core specimens were made with commercial perforator charges lined with copper cones to intercompare the penetrabilities of synthetic grouts with shales and reference rock types. Advanced charge designs using tapered thickness of the smoothly concave liner to achieve controlled, on-axis collapse and high-performance jets are analyzed by hydrodynamic computer methods, fabricated, and tested by experimental firing. Shock wave Hugoniot data observed in planar impact experiments on Devonian shale core specimens is systematized for future high-pressure penetration dynamics calculations by a theoretical model which includes mechanical unloading hysteresis and is guided by the known behavior of quartz.

118 (METC/SP--78/6(Vol.1), pp 347-359)
COMPUTATIONAL ANALYSIS OF THE EFFECT OF PULSE SHAPE ON THE FRACTURE OF DEVONIAN SHALE. McHugh, S.; Keough, D.D.; Seaman, L. (Poulter Lab., Menlo Park, CA). Oct 1978.
From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).
Explosive stimulation techniques increase permeability by forming multiple fractures, by extending existing fractures, or by employing both processes. Recent studies indicate that dynamic fracture is caused by a flaw activation and growth process controlled by the applied stress interacting with the material fracture parameters. Knowledge of this interaction allows the computation of the effectiveness of various loading techniques. Results of an analysis of pulse shape on fracture distributions are reported. The pulse shapes were chosen to vary the predicted crack size distributions, thereby indicating how the amount and location of damage depend on the pulse shape. The results of the analysis were compared with variations in the fracture distribution produced by changes in the fracture parameters to determine which features of the fracture distributions are sensitive to material property variations and which are sensitive to changes in the input pulse shape. Within the limits of the fracture model, it was determined that the amount and location of tensile cracking in a cylindrical geometry strongly depends on pulse shape. It was also found that optimizing the pulse shape to produce damage in specific locations does not require precise knowledge of the fracture parameters; however, the fracture parameters must be accurately known to quantify the amount of damage.

119 (METC/SP--78/6(Vol.1), pp 25-34)
INVESTIGATION OF HYDRAULIC FRACTURING TECHNOLOGY IN THE DEVONIAN SHALE. McKetta, S.F. (Columbia Gas System Service Corp., Columbus, OH). Oct 1978.
From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).
In two jointly sponsored Department of Energy (DOE) programs, Columbia Gas is investigating hydraulic fracturing techniques to enhance gas recovery from the impermeable, low pressure Devonian shale reservoir of the eastern United States. The scope of investigation encompasses varying the size of the hydraulic fracturing treatments from conventional to MHF type treatments and varying the components in the fracturing process from ''historical'' to novel treatments. The major purpose of this research effort is to delineate which treatment type will most effectively and efficiently promote gas production from the Devonian Shale. The type of hydraulic fracturing processes investigated include the use of foam, cryogens, and gelled water. To date, eight MHF treatments and eight cryogenic treatments have been conducted in six Columbia wells. Aspects of designing these treatments and the results obtained thus far from these research endeavors are discussed.

120 (METC/SP--78/6(Vol.1), pp 70-83)
RATIONALE FOR SHALE WELL STIMULATION. Young, C. (Science Applications, Inc., Fort Collins, CO). Oct 1978.
From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).
Successful stimulation of a gas reservoir whose porosity and permeability are largely due to a discrete natural fracture system requires an approach and concordant research efforts which are significantly different from those used for more conventional, homogeneous and isotropic reservoirs. Research and field efforts on stimulation of the Devonian Shales, carried out in the Eastern Gas Shales Project of the Morgantown Energy Technology Center, have identified many of the key elements required to develop successful stimulation technologies for fractured reservoirs. A review conducted by Science Applications, Inc., which included a workshop meeting held in Morgantown on 18 and 19 May, 1978, has further delimited these key elements and has provided recommendations for their integration into a

program to develop a stimulation rationale for shale wells. The development of successful stimulation methods for fractured reservoirs requires that: (1) the unique production characteristics of such reservoirs be understood and quantitatively described, (2) the optimum modifications to formation conditions and/or well-bore communication be determined, (3) the physical and chemical effect of various stimulation methods be identified and modeled, and (4) a program be implemented to fully integrate these three aspects. This integration will require close cooperation between reservoir engineers, stimulation developers and modelers, and field operators. The integrated efforts must include careful field monitoring of stimulation effects and consequent production behavior.

121 (METC/SP--78/6(Vol.1), pp 84-98) HYDRAULIC FRACTURE MODELING FOR THE EASTERN GAS SHALES PROGRAM. Advani, S.H. (Ohio State Univ., Columbus); GangaRao, H.V.S.; Chang, H.Y.; Komar, C.A.; Khan, S. Oct 1978.

From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).

Results from an ongoing West Virginia University and Department of Energy research effort on the simulation of hydraulic fracture models are presented. These models include the characterization of the coupled formation structural and fracturing fluid flow responses. The structural model is represented by layered linear elastic media subjected to in situ stress fields and fluid pressure on the vertical crack surface. The flow model includes the effects of flow rate, pumping pressure, fluid viscosity, fluid compressibility and formation reservoir properties. Predictive results for the estimation of the fracture width and area for selected Devonian shale formation properties and hydraulic fracturing treatment parameters are illustrated. In addition, design considerations related to penetration of cracks across layered media, bottom hole treatment pressure control, in situ stress effects, fluid leak-offs in the formation, and foam fracturing are discussed.

122 (SAND--77-1501) CALCULATIONS OF BOREHOLE SPRINGING IN OIL SHALE (ROCK SPRINGS SITE 6A). Kipp, M.E. (Sandia Labs., Albuquerque, NM (USA)). May 1979. Contract EY-76-C-04-0789. 41p. Dep. NTIS, PC A03/MF A01.

Explosive loading of a borehole has been considered as a means for preparing an oil shale bed for in situ retorting. Calculations of the oil shale response to a detonating column of explosive demonstrate that a significant region of the surrounding material experiences sufficient tensile stress to cause fracturing. A subsequent detonation in a prefractured region is shown to result in a negligible increase in fractured shale. Important requirements for future fracture are discussed.

123 (SAND--78-1002) EVALUATION OF FOUR SLURRY EXPLOSIVES PROPOSED FOR USE IN EXPLOSIVE FRACTURING OF OIL SHALE FORMATIONS. Neel, R.R.; Jacobson, R.D.; Ray, C.W. (Sandia Labs., Albuquerque, NM (USA)). Jun 1978. Contract EY-76-C-04-0789. 43p. Dep. NTIS, PC A03/MF A01.

The oil shale fracturing experiment conducted by Sandia Laboratories and the Laramie Energy Research Center at Site 12 of the Rock Springs, Wyoming, oil shale experiment area required an understanding of the flow and detonation characteristics of the explosive slurry selected for insertion into preformed hydraulic fractures. A series of tests were conducted to evaluate those characteristics for four candidate explosive slurries considered for that experiment. Two of the slurries flowed readily through medium (10/20 mesh) sand; two failed to flow through 10/20 sand but were capable of being pumped through coarse (8/12 mesh) sand. Tests were conducted which indicated that successful detonation can be achieved in cracks at least 1/8'' thick; however, each of the explosives failed to detonate satisfactorily in 1/16'' thick unfilled cracks, or sand filled cracks up to 3/8'' thick.

124 (SAND--78-1003) EXPLOSIVE EMPLACEMENT, ARMING, AND FIRING FOR OIL SHALE FRACTURING EXPERIMENTS AT LERC SITE 6A, ROCK SPRINGS, WYOMING. McEwen, L.W. (Sandia Labs., Albuquerque, NM (USA)). Aug 1978. Contract EY-76-C-04-0789. 16p. Dep. NTIS, PC A02/MF A01.

Arming and firing activities conducted by Sandia Laboratories in connection with oil shale fracturing experiments at Rock Springs, Wyoming are described. A special slurry explosive (DBA-1) was emplaced in three bore holes at different locations at LERC Site 6A. The three charges were detonated; the results were as expected.

125 (SAND--78-1233) FINAL REPORT OF DIVISION 1132 ARMING AND FIRING PROCEDURES FOR OIL SHALE RUBBLIZATION EXPERIMENTS AT SITE 12, ROCK SPRINGS, WYOMING. McEwen, L.W. (Sandia Labs., Albuquerque, NM (USA)). Oct 1978. Contract EY-76-C-4-0789. 58p. Dep. NTIS, PC A04/MF A01.

Arming and firing activity conducted in connection with Division 5734 oil shale rubblization experiments at Rock Springs, Wyoming, Site 12 is documented. The arming and firing system used to detonate the underground high explosives at Site 12 was basically the same system used to detonate underground nuclear tests at the Nevada Test Site. In this case, an interface and compatibility between the arming and firing system and Talley-Frac explosive had to be worked out with Talley-Frac, a company that has had oil field experience in the explosive oil-well stimulation business. The first attempt to conduct the experiment was unsuccessful because of complete failure of the detonators in a hostile environment. The detonators were replaced, and the second attempt was successful. As a result of this experiment, Division 1132 will develop a detonator/booster system that can survive hostile environments.

126 (SAND--78-1282) CONTINUUM FRACTURE AND FRAGMENTATION OF ROCK: APPLICATION TO OIL SHALE. Grady, D.E.; Kipp, M.E. (Sandia Labs., Albuquerque, NM (USA)). Jul 1978. Contract EY-76-C-04-0789. 41p. Dep. NTIS, PC A03/MF A01.

Progress on development of dynamic fracture, fragmentation, and stress wave propagation models specific to energy applications in rock is reported. Emphasis is focused on physical characterization of the fracture process and on improving computational efficiency. A description of the distribution of flaws characterizing fracturability of rock is quantified which leads to a rate-dependent fracture strength of rock. The resulting constitutive laws of fracture are examined in terms of processes of dynamic fracture in oil shale.

127 (SAND--78-1885) INSTRUMENTATION AND EVALUATION OF THE TALLEY ENERGY SYSTEMS, INC. OIL SHALE PROJECT. PART I. HYDRAULIC FRACTURE RESULTS. Beasley, R.R. (Sandia Labs., Albuquerque, NM (USA)). Apr 1979. Contract EY-76-C-04-0789. 143p. Dep. NTIS, PC A07/MF A01.

This is the first of two reports which describe the instrumentation and measurement techniques employed and present the data obtained during Phase I operations on the Talley Energy Systems, Inc., oil shale field project near Green River, Wyoming. Phase I operations included creation of four horizontal hydraulic fractures in the oil shale formation from a central wellbore drilled and cased through the formation and notched at each hydrofrac level, about seven feet apart. Asymmetry was relatively consistent, but direction of asymmetry was not as expected prior to hydrofrac operations. The methods of determining hydrofrac sizes correlated well with degree of asymmetry, but surface resistivity measurements beyond the first fracture did not work well because the first fracture retained conductive fluid and masked the growth of the subsequent fractures. Raw, processed, and interpreted data and the Site Activities Summary Log are presented in appendices.

128 (SAND--78-2008) DIRECT MEASUREMENT OF CHANGE IN WIDTH OF HORIZONTAL FRACTURES IN OIL SHALE. Warne, L.K.; Beasley, R.R.; Langdon, P.J.; Jacobson, A.K. (Sandia Labs., Albuquerque, NM (USA)). Dec 1978. Contract EY-76-C-04-0789. 43p. Dep. NTIS, PC A03/MF A01.

One potentially useful method to rubblize an oil shale bed in preparation for in situ processing is to insert and detonate slurry explosive in a pre-formed system of hydrofractures. This paper deals with an instrumentation effort undertaken to obtain a direct measurement of the widths of fractures during hydraulic fracturing and explosive insertion. The importance of such a measurement stems in part from its importance as an input parameter to a rubblization model. A total of four measurement systems are discussed in this paper, two of these were successfully used in the Talley Energy Systems Inc. (TESI) explosive event near Rock Springs, Wyoming. The results of these measurements are presented. The largest displacement measurement, .22 inches, was made with the hydraulic packer system. The largest displacement measured by the explosively anchored system was .20 inches. All measured displacements were consistent with downhole pressure fluctuations.

129 (SAND--78-2123C) TRIAXIAL MEASUREMENT OF STRESS WAVES IN THE FREE-FIELD. Reed, R.P. (Sandia Labs., Albuquerque, NM (USA)). 1979. Contract EY-76-C-04-0789. 22p. (CONF-790635--3). Dep. NTIS, PC A02/MF A01.

From 10. transducer workshop; Colorado Springs, CO, USA (12 Jun 1979).

In measurement of the free-field stress from a single spherical explosive, the stress wave has been characterized in terms of a simple scalar pressure or as a simple vector stress with a principal component in a fixed direction. In contrast, some present-day experiments involve measurements near multiple sources having distributed geometry and producing intermediate stress levels. For such experiments, it is necessary to recognize and measure the stress as a tensor quantity with principal stress directions that may change throughout the experiment. This paper reviews the characteristics of such dynamic stress fields and of the response of sensors to triaxial loading. Described is a prototype gage being developed for general field application where triaxial measurement is required. 5 figures, 1 table.

130 (SAND--78-2268C) TECHNIQUES AND PROBLEMS RELATING TO IN SITU MEASURMENT OF STRESS WAVES IN RUBBLIZATION EXPERIMENTS. Reed, R.P.; Boade, R.R. (Sandia Labs., Albuquerque, NM (USA)). 1979. Contract EY-76-C-04-0789. 13p. (CONF-790606--7). Dep. NTIS, PC A02/MF A01.

From 20. US symposium on rock mechanics; Austin, TX, USA (3 Jun 1979).

Stress waves propagating in rock adjacent to a rubblizing explosion can be monitored by several contemporary techniques. Measured properties of the waves are used to evaluate existing and improved fracturing methods and to document actual conditions of tests in the field. To be useful and economically justified, the measurement tools must be appropriate for the test objectives, they must be properly placed, and necessary conditions of application must be enforced. This paper describes conditions of the experiment and usefully measured properties of the stress field. It reviews the utility, capabilities, and conditions for application of time-of-arrival, displacement, velocity, acceleration, stress, and strain sensors applied to monitoring of rock rubblization experiments.

131 (SAND--79-0563C) OIL SHALE FRACTURE AND FRAGMENTATION AT HIGH RATES OF LOADING. Grady, D.E.; Kipp, M.E. (Sandia Labs., Albuquerque, NM (USA)). 27 Mar 1979. Contract EY-76-C-04-0789. 14p. (CONF-790606--8). Dep. NTIS, PC A02/MF A01.

From 20. US symposium on rock mechanics; Austin, TX, USA (3 Jun 1979).

Dynamic fracture and fragmentation data on oil shale obtained by various impact or explosive methods indicate significant rate dependence in fracture behavior. A model of the fracture process based on activation and growth of preexisting flaws has been successful in explaining the dynamic behavior and in correlating both static and dynamic tensile strength data for oil shale.

132 (SAND--79-0582C) BED PREPARATION CONCEPTS FOR TRUE IN SITU OIL SHALE PROCESSING: AN EVALUATION OF CURRENT TECHNOLOGY. Boade, R.R.; Stevens, A.L.; Harak, A.E.; Long, A. (Sandia Labs., Albuquerque, NM (USA); Department of Energy, Laramie, WY (USA). Laramie Energy Technology Center). 1979. Contract EY-76-C-04-0789. 18p. (CONF-790913--1). Dep. NTIS, PC A02/MF A01.

From 54. annual technical conference and exhibition; Las Vegas, NV, USA (23 Sep 1979).

True in situ methods to process oil shale, which by definition require no mining and depend on wellbores for access to the underground formation, will be successful only if techniques are available to transform the normally very tight oil shale seams into rubble beds that are sufficiently porous and permeable and composed of suitably sized fragments to permit effective retorting operations to be conducted. Prior experimental efforts to create such beds in comparatively deep formations, where significant void cannot be introduced by explosively lifting the overburden, have in nearly all cases employed either the wellbore springing or hydraulic/explosive fracturing concept. Only very limited success has ever been achieved in these efforts. In this paper,

reasons for the lack of success are identified. For the wellbore springing concept, the inherent cylindrical geometry is the primary difficulty in that it leads to small fractured zones because of rapid stress pulse attenuation, and also to regions of residual compressive stress around the wellbores which restrict fluid flow and hinder void redistribution. Major difficulties with the hydraulic/explosive fracturing concepts are that many important operations cannot be controlled and that regions of enhanced permeability are formed only in the immediate vicinity of explosive filled hydrofractures. The future success of true in situ processing depends on the introduction of void prior to the blasting operation and deployment of explosive in a geometry that will ensure distribution of the void.

133 EXPLOSIVE PLACEMENT FOR EXPLOSIVE EXPNSION TOWARD SPACED APART VOIDS. French, G.E. (to Occidental Oil Shale, Inc.). US Patent 4,146,272. 27 Mar 1979. Filed date 14 Sep 1977. 28p.

A subterranean formation containing oil shale is prepared for in situ retoring by initially excavating a pair of spaced apart voids, leaving an intervening zone of unfragemented formation between the voids. The intervening zone has substantially parallel free faces adjoining the void. A plurality of elongated blasting holes are formed in the intervening zone of unfragemented formation, the longitudinal axis of each blasting hole being substantially perpendicular to the parallel free faces of the intervening zone. At least two deck loads of explosives are placed in each blasting hole, with each load being longitudinally spaced apart from each adjacent load by stemming. The loads of explosive are then detonated in a single round of explosions with a time delay between adjacent loads for expanding formation in the intervening zones toward both voids. The fragmented mass of formation particles is then retorted tc recover shale oil frcm the oil shale.

134 CALCULATION OF OIL SHALE FRACTURES GENERATED BY A COLUMN OF EXPLOSIVE IN A BOREHOLE. Kipp, M.E. (Sandia Labs., Albuquerque, NM). pp 426-432 of High-pressure science and technology. Volume 2. Applications and mechanical properties. Timmerhaus, K.D.; Barber, M.S. (eds.). New York, NY; Plenum Press (1979).

From 6. AIRAPT international high-pressure conference; Boulder, CO, USA (25 Jul 1977).

The tensile fractures resulting from an end detonated column of explosive in an elastic--plastic medium tend to be maximized at the end opposite from the detonation point. Radial fractures are the dominant type observed in the present calculations, but a more refined anisotropic fracture model may amend that result. The relation between laboratory data obtained at high strain rates, and field experiments involving lower strain rates emerges as a significant factor in the extent of fractures calculated.

135 COMPUTER SIMULATION OF FRACTURE IN SMALL SCALE BOREHOLE EXPEERIMENTS IN OIL SHALE. Murri, W.J.; Curran, D.R.; Shockey, D.A.; Seaman, L.; Tokheim, R.E.; McHugh, S.L.; Young, C. (SRI International, Menlo Park, CA). pp 466-472 of High-pressure science and technology. Volume 2. Applications and mechanical properties. Timmerhaus, K.D.; Barber, M.S. (eds.). New York, NY; Plenum Press (1979).

From 6. AIRAPT international high-pressure conference; Boulder, CO, USA (25 Jul 1977).

The crack size distributions in 20-gal/ton and 40-gal/ton oil shale are comparable for nearly equal input conditions. The crack density showed little variation with depth in the 40-gal/ton oil shale. The density of small radial cracks near the borehole may be increased by an order of magnitude by detonating an explosive twice in the same borehole. The corresponding permeability increases nearly five orders of magnitude with each detonation. The results of the small-scale borehole experiments have demonstrated important advantages over other techniques. The shock-loaded oil shale is easily sectioned on arbitrary planes, readily providing a thorough, three-dimensional picture of the extent of fracture and fragmentation. Instrumentation with stress or strain gages, or both, is relatively simple and straightforward. The smallness of the specimens is conducive to postexperiment permeability measurements. Such small-scale experiments should continue in order to supplement and help guide large-scale field experiments. 8 figures.

136 COMPUTATIONAL MODEL FOR EXPLOSIVE FRACTURE OF OIL SHALE. Shockey, D.A.; Murri, W.J.; Tokheim, R.E.; Young, C.; McHugh, S.L.; Seaman, L.; Curran, D.R. (SRI International, Menlo Park, CA). pp 473-482 of High-pressure science and technology. Volume 2. Applications and mechanical properties. Timmerhaus, K.D.; Barber, M.S. (eds.). New York, NY; Plenum Press (1979).

From 6. AIRAPT international high-pressure conference; Boulder, CO, USA (25 Jul 1977).

Mathematical equations were derived to describe the three stages of dynamic fracture: crack nucleation, crack coalescence, and fragmentation. Plate-impact experiments were performed. Agreement between computed and observed fragment size distributions is encouraging. 6 figures, 2 tables. (DLC)

OIL PRODUCTION, RECOVERY, AND REFINING

137 (BNL--51002, pp 41-60) OIL SHALE: PROCESS DESCRIPTION AND EFFLUENT CHARACTERIZATION. Coomes, R.M. (Tosco Corp., Los Angeles, CA). Mar 1979.

From Symposium on assessing the industrial hygiene monitoring needs for the coal conversion and oil shale industries; Upton, NY, USA (5 Nov 1978).

Various methods of processing oil shales are described. The possibility of potential exposure of workers to vapors, dusts or mists is described. Colony has been concerned with the potential health effects of oil shale processing, and contracted our first health-related studies to outside laboratories in 1965. Since that time, over $500,000 has been invested in chemical characterization and biological testing of oil shale materials. We have tested raw oil shale, TOSCO II processed shale, crude shale oil, hydrotreated shale oil, and TOSCO II atmospheric effluent for their toxicity and carcinogenicity. It is concluded from these experimental results that crude shale oil presents a carcinogenic hazard similar to or less than that of currently used petroleum products, that hydrotreating dramatically reduces this carcinogenicity, and that solid oil shale materials do not present a carcinogenic hazard.

138 (CONF-7810176--, pp 163-185) PRODUCTION OF LIQUID FUELS FROM OIL SHALE. Alley, S.K.

(Union Oil Co. of California, Brea). Jun 1979.

From Conference on composition of transportation synfuels: R and D needs, strategies and actions; San Antonio, TX, USA (11 Oct 1978).

An overview of oil shale resources, retorting concepts, and refining technologies indicates that, while oil shale is a significant resource, Union Oil Company's prototype plant demonstrates that the industry is not ready to assume commercialization. Four retorting processes now under consideration are the Petrosix process, Paraho kilm, Tosco II process, and the Union Oil Company's upflow of solids. Refining techniques are being developed for the removal of solids and arsenic as well as for hydrotreating to reduce nitrogen content. Several other schemes are outlined for upgrading raw shale, the choice of scheme depending on the intended use of the finished fuel. A political atmosphere conducive to this type of development is necessary before shale oil can become competitive.

139 (CONF-7810176--, pp 187-193) COMPOSITION OF TRANSPORTATION SYNFUELS. Jackson, R.G. (Continental Oil Co., Ponca City, OK). Jun 1979.

From Conference on composition of transportation synfuels: R and D needs, strategies and actions; San Antonio, TX, USA (11 Oct 1978).

The author considers oil shale or coal gasification to be the only viable near-term source of transportation synfuels and outlines an approach for building on present technology. Those processes which can produce liquid fuels with a minimum of modification and loss of energy should be emphasized. Government participation should be to establish a goal (such as one million barrels per day of synfuel production by 1990) and create a limited market in which all unconventional sources can compete freely without mandated quotas. Research priority should go to automotive fuels to keep pace with engine research.

140 (CONF-7810176--, pp 379-394) DIRECTION FOR SYNFUELS R and D: FINAL SUMMARY PANEL. Fleming, R.D. (Department of Energy, Washington, DC); Brinkman, D.W.; Taylor, W.R.; Paraskos, J.A.; Ryan, D.; Colucci, J.M.; Baker, R.E.; Pefley, R.K. Jun 1979.

From Conference on composition of transportation synfuels: R and D needs, strategies and actions; San Antonio, TX, USA (11 Oct 1978).

Each of the major sectors participating in the conference on transportation synfuels was represented on the final panel to make relevant comments. Some noted that the major obstacles to a commercial synfuel industry appear to be non-technical, although industry can help to reduce some of those obstacles by providing technical feasibility. Their attitude was one of Lets get on with it. Other speakers stressed the need for more basic research on fuel characteristics and refining, the use of a systems approach, and greater financial support from the government. Several speakers contributed their personal concerns during the open discussion.

141 (DOE/ET--0087) FOSSIL ENERGY PROGRAM SUMMARY DOCUMENT. (Department of Energy, Washington, DC (USA)). Mar 1979. 484p. Dep. NTIS, PC A21/MF A01.

The programs and projects involving the fossil energy resources of the United States (coal, petroleum, natural gas, and oil shales) are described in detail. The primary emphasis of the Fossil Energy Program is on coal, the most abundant natural resource. Activities in this area include mining research and development, coal liquefaction and gasification, advanced environmental control technology, heat engines and recovery, combustion systems, fuel cells, and magnetohydrodynamics. For petroleum the activities stressed are enhanceed oil recovery, oil shale technology, drilling and offshore technology, and advanced process technology. For natural gas the emphasis is on recovery from unconventional sources such as tight sandstones and shales. Commercialization, environmental, and socio-economic issues involved in these activities are of prime consideration. The contributions of the energy technology centers and national laboratories to the overall goals of the Fossil Energy Program are summarized. International programs on the production and utilization of fossil fuels are described. The requested funding for FY 1980 is $747.6 million, of which $662.7 million is planned for coal, $57.4 million for petroleum, and $27.6 million for gas. (JSR)

142 (DOE/TIC--10561) INCENTIVES FOR SYNTHETIC FUELS. FINAL REPORT. Sponsler, G.C. (International Planning Management Corp., Bethesda, MD (USA)). 31 Jul 1975. 114p. Dep. NTIS, PC A06/MF A01.

COAL GASIFICATION;COAL LIQUEFACTION;SHALE OIL;LOW BTU GAS;HIGH BTU GAS;COMMERCIALIZATION; FINANCIAL INCENTIVES;PILOT PLANTS;DEMONSTRATION PLANTS

143 (PUB--304) EROSION/CORROSION NEWSLETTER. Levy, A.V. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). May 1979. Contract W-7405-ENG-48. 20p. Dep. NTIS, PC A02/MF A01.

Research in corrosion/erosion is reported including steep angle impingement corrosion, particle trajectory analysis of gas-solid particle mixtures in a curved duct, plasticity in corrosion of ductile metals, erosion behavior of oxide scales, corrosion of SS-310, effect of water vapor and crystal orientation on the performance of a sulfur probe based on CaF_2 electrolyte, solid state probe for SO_2/SO_3 based on Na_2SO_4I electrolyte, and corrosion of alloys in oil shale retorting. (FS)

144 (UCID--18048) DEVELOPMENT OF A LOCAL VOID-DEFECT MODEL WHICH ACCOUNTS FOR YIELD LOSSES CAUSED BY FLOW NONUNIFORMITIES. Lyczkowski, R.W. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 2 Feb 1979. Contract W-7405-ENG-48. 25p. Dep. NTIS, PC A02/MF A01.

This report quantifies the specifics of T.R. Galloway's local void-defect-induced flow maldistribution model for the retorting of wide size-range oil shale particles. A first level void-defect model was developed which appears to be capable of quantifying oil yield losses caused by flow nonuniformities. (DLC)

145 HYDROCARBON CONVERSION WITH AN ACTIVATED MULTIMETALLIC CATALYTIC COMPOSITE. Antos, G.J. (to UOP Inc.). US Patent 4,152,247. 1 May 1979. Filed date 9 Jan 1978. 26p.

Hydrocarbons are converted by contacting them at hydrocarbon conversion conditions with a novel activated multimetallic catalytic composite comprising a combination of a catalytically effective amount of a pyrolyzed rhodium carbonyl component with a porous carrier material containing a uniform

dispersion of a catalytically effective amount of a platinum group component which is maintained in the elemental metallic state. In a highly preferred embodiment, this novel catalytic composite also contains a catalytically effective amount of a halogen component. The platinum group component, pyrolyzed rhodium carbonyl component and optional halogen component are preferably present in the multimetallic catalytic composite in amounts, calculated on an elemental basis, corresponding to about 0.01 to about 2 wt. % of the uniformly dispersed platinum group metal, about 0.01 to about 2 wt. % of carbonyl-derived rhodium and about 0.1 to about 3.5 wt. % of halogen. A key feature associated with the preparation of the catalytic composite is reaction of a rhodium carbonyl complex with a porous carrier material containing a uniform dispersion of a platinum group metal maintained in the elemental state, whereby the interaction of the rhodium moiety with the platinum group moiety is maximized due to the platinophilic (i.e. platinum-seeking) propensities of the carbon monoxide ligand used in the rhodium reagent. A specific example of the type of hydrocarbon conversion process disclosed herein is a process for the catalytic reforming of a low octane gasoline fraction wherein the gasoline fraction and a hydrogen stream are contacted with the subject activated multimetallic catalytic composite at reforming conditions.

146 INTEGRATED PROCESS FOR THE PARTIAL OXIDATION-THERMAL CRACKING OF CRUDE OIL FEEDSTOCKS. Kamm, G.R.; Tanaami, K. (to Union Carbide Corp.). US Patent 4,134,824. 16 Jan 1979. Filed date 7 Jun 1977. 8p.

An integrated partial oxidation-thermal cracking process is disclosed for the more complete utilization of all chemical values in crude oil feedstocks employed in the concurrent production of synthesis gas and an olefin-rich stream comprising the steps of: burning, at a high temperature, streams of fuel and oxygen in the presence of superheated steam to form a reducing stream of hot combustion products; injecting a crude oil distillate fraction stream into said reducing stream of hot combustion products; passing the resulting injected stream to a reaction zone to effect thermal cracking of said crude oil distillate fraction steam and reaction products; thermally quenching said stream; removing pitch and fractionating to provide at least one stream of hydrocarbon oil and an olefin rich gas stream; separating carbon dioxide and any contained hydrogen sulfide from said olefin rich gas stream, separating streams of synthesis gas, methane and ethylene from said olefin rich gas stream; and recycling fractions of said methane stream as fuel to said burning step.

147 ECONOMIC FEASIBILITY OF SHALE OIL: AN ACTIVITY ANALYSIS. Ericsson, N.R. (London School of Economics and Political Science); Morgan, P. Bell J. Econ.; 9: No. 2, 457-487(Aut 1978).

Given the current state of technology, the existing resource supplies, and environmental constraints, the authors examine how much shale oil could be profitably produced in the Western United States, what processes would be used, and which constraints would be binding in long-run equilibrium. Using an activity analysis model, they show that production of over 15 million barrels of shale oil per day (five-sixths of present U.S. oil consumption) is a profitable activity when the price of oil is only $18 per barrel (1975 dollars). In testing the sensitivity of the results, they find that, even under quite conservative assumptions, production of two million barrels per day is economically feasible in the long run when the selling price of oil exceeds $12 per barrel. 41 references.

148 CORRELATION BETWEEN OIL YIELDS OF OIL SHALES AND ^{13}C NUCLEAR MAGNETIC RESONANCE SPECTRA. Maciel, G.E.; Bartuska, V.J.; Miknis, F.P. (Colo State Univ, Fort Collins). Fuel; 57: No. 8, 505-506(Aug 1978).

Using the cross polarization/dipolar decoupling method, ^{13}C NMR spectra have been obtained on twenty oil shales and kerogens from around the world. A correlation is found between the integrated signal intensity of the aliphatic region of the spectra and the oil yields of the shales. 6 refs.

149 AMERICAN CHEMICAL SOCIETY, DIVISION OF PETROLEUM CHEMISTRY, PREPRINTS, VOLUME 23 NUMBER 1 FEBRUARY 1978: GENERAL PAPERS, SYMPOSIUM ON THERMAL HYDROCARBONS CHEMISTRY, PAPERS FROM CHICAGO MEETING, AUGUST 23--SEPTEMBER 2 1977: SYMPOSIUM ON LABORATORY AND BENCH SCALE REACTOR DESIGN, SYMPOSIUM ON FEDERAL ENERGY POLICY AND PROVATE R AND D. Gould, J.R. (Ed.). (API, Washington, DC). Am. Chem. Soc., Div. Pet. Chem., Prepr.; 23: No. 1, vp(Feb 1978).

This symposium of 39 papers covers the following topics: separation of nitrogen materials from bitumen; the kinetics of hydrodesulfurization; analysis of catalysts; lubricating oil stabilization; thermal hydrocarbon chemistry; refining of synthetic crudes; laboratory and bench scale reactor design; and, federal energy policy and private RandD. Selected papers are indexed separately.

IN SITU METHODS, TRUE AND MODIFIED

150 (DOE/EV--0046(Vol.1), pp 292-307) INTEGRATED COMPLIANCE AND CONTROL TECHNOLOGY RESEARCH ACTIVITIES FOR IN SITU FOSSIL FUEL PROCESSING EXPERIMENTS. Farrier, D.S.; Harrington, L.W.; Poulson, R.E. (Dept. of Energy, Laramie, WY). Sep 1979.

From Environmental control symposium; Washington, DC, USA (28 Nov 1978).

Fossil fuel processing research facilities must comply with Federal and state regulatory standards. In addition, the experimental sites provide research opportunities to evaluate control needs and then design and demonstrate control measures as each technology approaches commercialization. This paper summarizes the regulatory compliance and control technology activities and illustrates their integration as pertaining to field in situ recovery experiments for oil shale.

151 (DOE/EV--0046(Vol.1), pp 323-333) STRATEGY FOR THE ABANDONMENT OF MODIFIED IN-SITU OIL SHALE RETORTS. Fox, J.P. (Lawrence Berkeley Lab., CA); Persoff, P.; Moody, M.M.; Sisemore, C.J. Sep 1979.

From Environmental control symposium; Washington, DC, USA (28 Nov 1978).

Burned out oil shale retorts need to be stabilized to prevent subsidence of the overburden and the ground surface; prevent gas leakage; maximize resource utilization; and provide subsurface disposal of spent shale that has been retorted on the surface and minimize ground water contamination. In order to stabilize the retorts, the following strategy should be followed. (1) Characterize the components of the retort such as overburden and

pillar strength; temperature effect on strength; retort and pillar permeability; and rubble behavior during and after retorting. (2) Develop slurry that can accommodate a maximum amount of spent shale and low quality water. (3) Investigate techniques for emplacing the grout and sealing the retorts. (4) Develop a retort cooling process whereby sensible heat can be recovered and the residual rubble will have properties amenable to grouting. (5) Prepare a full scale field test program to evaluate the optimum combination of cooling procedures, grout and emplacement techniques.

152 (FE--1747-1) BX IN SITU OIL SHALE PROJECT. QUARTERLY TECHNICAL PROGRESS REPORT, MARCH 1--MAY 31, 1977. (Equity Oil Co., Salt Lake City, UT (USA)). 10 Jun 1977. Contract ET-78-F-03-1747. 10p. Dep. NTIS, PC A02/MF A01.

Objective is to demonstrate the feasibility of using superheated steam as a heat-carrying medium to retort in-situ the oil shale in the Green River Formation ''leached'' zone and provide a mechanism for the recovery of this shale oil with a minimum impact on the environment. Specific tasks included: The drilling and coring of two core holes for site evaluation; the design of the vertical communication test; discussions concerning the laboratory experimentation program; reactivation of a mathematical model for analyzing in situ retorting; and the preparation of an Environmental Research Plan (ERP) for the project.

153 (FE--1747-2) BX IN SITU OIL SHALE PROJECT. QUARTERLY TECHNICAL PROGRESS REPORT, JUNE 1--AUGUST 31, 1977. Dougan, P.M. (Equity Oil Co., Salt Lake City, UT (USA)). 15 Sep 1977. Contract ET-78-F-03-1747. 18p. Dep. NTIS, PC A02/MF A01.

The objective is to demonstrate the technical feasibility of using superheated steam to retort in-situ the oil shale in the Green River Formation leached zone. Work during this quarter was confined primarily to the tasks concerned with site evaluation; this included the drilling of two core holes (BX-12 and -13) and the performance and evaluation of a vertical communication test. (DLC)

154 (FE--1747-3) BX IN SITU OIL SHALE PROJECT. QUARTERLY TECHNICAL PROGRESS REPORT, SEPTEMBER 1--NOVEMBER 30, 1977. Duncan, P.M. (Equity Oil Co., Salt Lake City, UT (USA)). 15 Dec 1977. Contract ET-78-F-03-1747. 33p. Dep. NTIS, PC A03/MF A01.

Work focused on the tasks related to laboratory experimentation; project reactivation; mathematical modeling; design and installation of the instrumentation system; project design and construction; and environmental monitoring. Specific activities related to each of these principal task areas are reported.

155 (FE--1747-5) BX IN SITU OIL SHALE PROJECT. QUARTERLY TECHNICAL PROGRESS REPORT, MARCH 1--MAY 31, 1978. Duncan, P.M. (Equity Oil Co., Salt Lake City, UT (USA)). 20 Jun 1978. Contract ET-78-F-03-1747. 41p. Dep. NTIS, PC A03/MF A01.

Work on the BX In Situ Oil Shale Project consisted of finalization of design for instrumentation, well spacing, and equipment layout; the beginning of the drilling of injection and production wells; and the finalization of a contract with Stearns Roger Corporation to provide operating personnel for the project.

156 (FE--1747-7) BX IN SITU OIL SHALE PROJECT. QUARTERLY TECHNICAL PROGRESS REPORT, SEPTEMBER 1--NOVEMBER 31, 1978. Dougan, P.M. (Equity Oil Co., Salt Lake City, UT (USA)). 15 Dec 1978. Contract ET-78-F-03-1747. 66p. Dep. NTIS, PC A04/MF A01.

The construction of surface facilities at the BX In Situ Oil Shale Project continued during the quarter. All Project wells were completed, and the first tests using the flow retorting system of the Laboratory Research Program were conducted. Pre-startup environmental monitoring continued and the first quarterly report on air resources was prepared.

157 (FE--2234-T1) MATHEMATICAL MODELING OF IN SITU OIL SHALE RETORTING. FINAL REPORT. George, J.H.; Harris, H.G. (Wyoming Univ., Laramie (USA)). Jan 1978. Contract EX-76-S-01-2234. 28p. Dep. NTIS, PC A03/MF A01.

Under the general objective of developing mathematical models to describe the recovery of oil from oil shale using in-situ retorting techniques, the following tasks have been completed: (1) An improved kinetic model of kerogen decomposition has been developed and coded for use by Department of Energy (DOE) personnel. A general program has been coded to obtain optimum kinetic constants for ten reacting substances and twenty separate reactions. This program has been used to analyze and compare existing models for kerogen decomposition. (2) Time--temperature profiles and oil yields predicted by the basic Laramie Energy Technology Center (LETC) model have been significantly improved by allowing oil to be retained and combusted by permitting air to channel around the main combustion zone. A program incorporating these effects is currently available for use by DOE personnel. The carbon combustion mechanism has been investigated thoroughly; a closed form solution has been obtained for the steady shrinking core model (to replace an iterative solution), and the complete free boundary problem has been numerically solved. This exact solution indicates that as shale particle size increases, significant differences appear between the steady state and the free boundary solution. Several methods have been programmed for obtaining the free boundary solution to the shrinking core problem. (3) A control strategy has been developed to optimize several parameters, including oil yield and cost per barrel of oil. Control variables include the rate of injection of air and recycle gas. A program is available by contacting the authors.

158 (FE--2343-6(Vol.2)) REVIEW AND ANALYSIS OF OIL SHALE TECHNOLOGIES. VOLUME II. TRUE IN SITU TECHNOLOGY. Jee, C.K.; White, J.D.; Bhatia, S.K.; Nicholson, D. (Booz-Allen Applied Research, Inc., Bethesda, MD (USA)). Aug 1977. Contract EX-76-C-01-2343. 102p. Dep. NTIS, PC A06/MF A01.

This volume is a technical review and economic analysis of current true in-situ shale technology. Three techniques involving different fracturing methods are compared. Key variables include air compression, drilling depth, drill hole diameter and pattern geometry, shale grade, shale bed thickness, and explosives requirements. Variables, process systems, and process steps defined for each fracturing technique are scaled up to a 64,000-bbl/day facility and costed to provide a basis for evaluating relative economic feasibility. Capital investment, capital depreciation,

annual operating, and crude shale oil costs are estimated and compared. The economic evaluation reveals that the choice of fracturing technique does not have any significant effect on the crude oil shale prices estimated for the scaled-up facilities. The costs per barrel vary only about 10%, with the lowest being the facility using the wellbore springing-explosive technique at $19 and the highest being the facility using the underreaming-explosive technique at $21. From a technical standpoint, the combination of hydraulic fracturing and explosive rubblization has the best potential for improvement. A major finding in this evaluation is that high costs associated with compression of the injection gas and drilling strongly influence process economics and, subsequently, crude oil selling prices for all techniques. The actual amount of oil recovered or extracted from the shale is also a major economic factor. The study concludes that the logistics of a commercial operation and the inability to create adequate permeability and surface area by any of the three fracturing techniques evaluated appear to be limiting factors, and that current technology has little potential for technical or economic success. 25 tables, 17 figures.

159 (FE--2343-6(Vol.3)) REVIEW AND ANALYSIS OF OIL SHALE TECHNOLOGIES. VOLUME III. MODIFIED IN SITU TECHNOLOGY. Jee, C.K.; White, J.D.; Bhatia, S.K.; Nicholson, D. (Booz-Allen Applied Research, Inc., Bethesda, MD (USA)). Aug 1977. Contract EX-76-C-01-2343. 56p. Dep. NTIS, PC A04/MF A01.

The modified in situ process evaluated in this volume of the report is the Rubble In Situ Extraction (RISE) method, which is being developed by the Lawrence Livermore Laboratory (LLL). Although another modified in situ method has been successfully demonstrated (by Occidental Petroleum Corporation), that method was not evaluated because much of the information needed to perform the assessment is proprietary. The technical evaluation of the RISE process, which is in the conceptual stage of development, reveals that it offers a promising method for creating the necessary permeability in the zone to be retorted. The RISE process is expected to create the necessary permeability and surface area for retorting. The process appears to be technically feasible and is considered a viable candidate for commercialization. Economic success, however, depends on the grade of shale to be processed. The process may be economically more attractive at high shale grades, but the technical viability at the high grades needs to be demonstrated. Key technical problems must also be resolved. These problems are expected to be retort creep and surface subsidence. Even though these problems cannot be completely eliminated, optimized retort size, shale grade, and particle-size range are expected to mitigate these effects. Future R and D efforts should focus on these problem areas and should include the appropriate field tests.

160 (FE--2346-20(App.)) DOW SHALE SITE TRACER GAS PRESSURIZATION STUDY. FINAL REPORT. APPENDIX: ENERGY FROM IN SITU PROCESSING OF ANTRIM OIL SHALE. Peterson, E.W.; Lagus, P.L. (Systems, Science and Software, La Jolla, CA (USA)). Oct 1977. Contract EX-76-C-01-2346. 90p. (SSS-R--78-3442). Dep. NTIS, PC A05/MF A01.

A series of tracer gas pressurization experiments were undertaken at the Dow shale site at Peck, Michigan. The study was conducted to evaluate flow communication between boreholes open to both the Antrim and False Antrim layers of the retort volume, determine permeability and porosity distributions within the retort volume, and to assess qualitatively the uniformity of the fracturing or rubblization within the retort volume. Results show that the system is non-uniform. Flow from Well No. 4 to the other wells occurs primarily through various flow channels. These channels open when the wellhead pressure approaches the overburden pressure and appear closed at lower pressures. Consequently, the system is pressure sensitive and the flow is enhanced at elevated system pressures. Flow to outlying wells, such as No. 8 and No. 10, occurred only when Well No. 3 was at an elevated pressure. When the system approached steady state, as indicated by an absence of pressure changes, the production rate was about $^1/_3$ the injection rate. Multiple tracer gas injection into Well No. 4 at various depths demonstrated conclusively that flow does occur through the Antrim formation in the vicinity of Well No. 4. The permeability and porosity found in the vicinity of Well No. 4 was k approximately 0.045 millidarcy and phi approximately = 0.1 for a radius <1.75 ft and approximately 0.001 for radii greater than 1.75 ft. The major flow from Well No. 4 is toward Well No. 3, which in turn communicates readily with Wells No. 5 and No. 6. This flow occurs as a slug flow.

161 (FE--2346-23) LEGAL PROBLEMS INCIDENT TO THE COMMERCIALIZATION OF IN SITU PROCESSING OF MICHIGAN ANTRIM SHALE. Meyers, V.N. (Mika, Meyers, Beckett and Jones, Grand Rapids, MI (USA)). Apr 1978. Contract EX-76-C-01-2346. 53p. Dep. NTIS, PC A04/MF A01.

This report undertakes to analyze the legal problems that will be confronted along the road to commercialization of hydrocarbon production from the Antrim shale in Michigan by in-situ processing methods. Much of the legal framework from which significant decisions must be made is woefully sparse and will require considerable judicial interpretation as well as legislative action. However, in many areas such as zoning, environmental impact statements, use of explosives, air pollution and waste disposal a reasonably well defined legal framework exists within which in-situ processing of the Antrim shale in Michigan may proceed. The legal problems discussed relate to the method of in-situ processing of the Antrim shale described at the outset of this report. Should the method or technology of recovery undergo substantial or radical change, the conclusions reached in this report should be reviewed in light of the changed method or technology.

162 (FE--2346-28) ENVIRONMENTAL MONITORING AND ANALYSIS IN SUPPORT OF ANTRIM OIL SHALE RESEARCH. TOPICAL REPORT, MARCH 1977--FEBRUARY 1978. Istvan, L.B.; Haack, B.N.; Sampson, R.E.; Tanis, F.J. (Environmental Research Inst. of Michigan, Ann Arbor (USA)). Mar 1978. Contract EX-76-C-01-2346. 103p. Dep. NTIS, PC A06/MF A01.

This report covers the first year of an expected four year program. Activities included: monitoring of surface elevations for possible subsidence; monitoring for soil contamination from brines; monitoring surface and subsurface water quality; and monitoring ambient air quality for oxides of nitrogen, sulfur dioxide, hydrocarbons, methane, carbon monoxide, and particulates. Assessment was also made of site vegetation, local hydrology, surface disruption caused by drilling activities, and impacts on neighboring residents. Much of this year's effort was directed to establishing baseline conditions. Consequently, assessment of many

potential impacts is not yet possible. However, preliminary results indicate that hydrofracturing operations did not affect surface elevations, and that the experimental operations, including flaring of combustion product gases, did not degrade ambient air quality beyond permissible concentrations. Negative impacts noted include minor inconvenience to neighboring residents, and physical disruption of the land surface. Use of electrical conductivity probes to monitor for brine contamination of the soil gave inconclusive results. The need for evaluation of possible contamination of deep ground waters was also identified. Surface water quality data is not yet adequate to allow assessment of possible impacts from the in situ experiment. 18 tables.

163 (FE--2346-29) ENERGY FROM IN SITU PROCESSING OF ANTRIM OIL SHALE. Humphrey, J.P. (Dow Chemical Co., Midland, MI (USA). Hydrocarbons and Energy Research Dept.). 19 Jul 1978. Contract EX-76-C-01-2346. 44p. Dep. NTIS, PC A03/MF A01.

In situ combustion was maintained for a 61-day period while several continuous and cyclic production procedures were tested. Gas having energy values in the target range (150 Btu scf) was produced at various times, although the flow rate at these times was minimal and hence the energy production was low. Thus, a large area ignition did not occur, probably due to the lack of extensive fracturing in the area. There was no significant heat damage to the propane burner, whereas in the previous run the burner was severly damaged. A hydraulic fracturing and sand propping program was completed in the 100 Series wells. Evaluation of the results shows that communication has been achieved between the various wells. Preparations for explosive fracturing of this system are essentially complete. The plans for the first explosive shot in the explosive underreaming experiment have been completed and final preparations are underway. Shale characterization and resource inventory activities are continuing in four of the major universities of Michigan.

164 (FE--2346-34) ENERGY FROM IN SITU PROCESSING OF ANTRIM OIL SHALE. QUARTERLY TECHNICAL PROGRESS REPORT, JULY--SEPTEMBER 1978. Washington, L.J. Jr. (Dow Chemical Co., Midland, MI (USA)). 19 Oct 1978. Contract EX-76-C-01-2346. 52p. Dep. NTIS, PC A04/MF A01.

The objective of this contract is to test the technical feasibility for the in situ processing of the Antrim oil shale within the Mississippian--Devonian black shale sequence of the Michigan Basin to produce energy values. In the report quarter explosive fracturing experiments were conducted in the wells involved in the explosive underream series and in the hydrofracture series. In total, four successful shots were made. In Well No. 301, a 20 foot section of well bore was enlarged to almost three times its original volume by the detonation of 1500 pounds of explosive. Wells No. 101, 104, and 106 were also explosively fractured. Preparations for fracturing Wells No. 103 and 105 are complete. In lab tests for the chemical underream experiment, a 4 foot zone was found to have a uniform and high hydrochloric acid solubility. Notching, fracturing, and acid underreaming experiments will be concentrated in this area. Data from the extraction trials on the front site have been compiled and plotted. A topical report on this experiment is being prepared. Two new methods of igniting shale were tested. Shale characterization and resource inventory activities continued at four major Michigan universities.

165 (FE--2346-38) ENERGY FROM IN SITU PROCESSING OF ANTRIM OIL SHALE. QUARTERLY TECHNICAL PROGRESS REPORT, OCTOBER--DECEMBER 1978. Washington, L.J. Jr. (Dow Chemical Co., Midland, MI (USA). Hydrocarbons and Energy Research Dept.). 19 Jan 1979. Contract EX-76-C-01-2346. 46p. Dep. NTIS, PC A03/MF A01.

Explosive fracturing activities for the hydraulic fracturing subtask were completed in the 100 series wells. Well cleanout was almost completed and permeability studies and fracture evaluation will proceed as soon as it is complete. Evidence that there is communication between these wells continues to accumulate. The third and fourth shots in the explosive underreaming series were detonated in Well Number 301. The well cavity was was increased by a factor of 2.4 compared to the original borehole volume for a 62 foot section after the third shot. The fourth shot produced more damage to the bottom section of well casing. For the chemical underreaming subtask, Well Number 201 was notched in a limestone stringer below the Antrim formation. The well was hydrofractured with water but no communication with nearby wells was observed. The data from the extraction trials on the front site have been collected and processed in the preparation of a full report of these experiments. Some of the data are summarized in this report. Analysis of product gases from the final trial showed that they had a total energy content 4.9 times the total solid fuel and gaseous fuel put into the well for ignition, thus establishing that significant quantities of Antrim shale had been affected by the operation.

166 (FE--2346-44) ENERGY FROM IN SITU PROCESSING OF ANTRIM OIL SHALE. QUARTERLY TECHNICAL PROGRESS REPORT, JANUARY--MARCH 1979. Washington, L.J. Jr. (Dow Chemical Co., Midland, MI (USA). Hydrocarbons and Energy Research Dept.). 20 Mar 1979. Contract EX-76-C-01-2346. 45p. (DOW/SRPR--44). Dep. NTIS, PC A03/MF A01.

Permeability studies on the 100 series wells, which had been hydraulically and then explosively fractured, have shown much greater communication between wells and much greater permeability than had been present in the wells on the existing site during the 1978 extraction trials. Well No. 301, which is the central well in the explosive underreaming series, was cleaned out. Two wells were drilled and cored nearby. Extensive fracturing due to the use of explosives in Well No. 301 was evident in the well located 15 feet from the site of the explosive treatment. Communication between these wells is also evident. A downhole methane burner of Tejas Petroleum Engineers was successfully tested under realistic operating conditions in an existing well. Other preparations for the planned extraction trial are continuing.

167 (FE--2346-44) ENERGY FROM THE SITU PROCESSING OF ANTRIM OIL SHALE. QUARTERLY TECHNICAL PROGRESS REPORT, JANUARY-MARCH, 1979. Washington, L.J. Jr. (Dow Chemical Co., Midland, MI (USA). Hydrocarbons and Energy Research Dept.). 20 Mar 1979. Contract EX-76-C-01-2346. 45p. Dep. NTIS, PC A03/MF A01.

Permeability studies on the 100 series wells, which had been hydraulically and then explosively fractured, have shown much greater

communication between wells and much greater permeability than had been present in the wells on the existing site during the 1978 extraction trials. Well number 301, which is the central well in the explosive underreaming series, was cleaned out. Two wells were drilled and cored nearby. Extensive fracturing due to the use of explosives in Well number 301 was evident in the well located 15 feet from the site of the explosive treatment. Communication between these wells is also evident. A downhole methane burner of Tejas Petroleum Engineers was successfully tested under realistic operating conditions in an existing well. Other preparations for the planned extraction trial are continuing.

168 (LA--7492-P) GROUND WATER USE AND FOSSIL FUEL CONVERSION. Loose, V.W. (Los Alamos Scientific Lab., NM (USA)). Oct 1978. Contract W-7405-ENG-36. 9p. Dep. NTIS, PC A02/MF A01.

A three-phased study is proposed to identify the residuals emanating from underground fossil fuel conversion facilities and to study their effect upon ground water reservoirs. Based on this hydrologic and geophysical information, it is proposed to assess the environmental, policy, and economic effects of underground fossil fuel conversion.

169 (LA-UR--79-88) EMPIRICAL CHARACTERIZATION OF OIL SHALE FRAGMENTATION EXPERIMENTS. Schmidt, S.C.; Edwards, C.L.; Oliver, R.; Johnson, J.N.; Wagner, P. (Los Alamos Scientific Lab., NM (USA); Rio Blanco Oil Shale Co., Denver, CO (USA)). 1979. Contract W-7405-ENG-36. 16p. (CONF-790218--1). Dep. NTIS, PC A02/MF A01.

From 5. annual conference on explosives and blasting technology; St Louis, MO, USA (7 Feb 1979).

Shale oil recovery rates that can be achieved in underground in situ retorts can be strongly influenced by the shale breakage and fragment-size distribution achieved during rubblization. Since the fragmentation pattern in the retort is a direct result of the blast design used for rubblization, the characterizing blast parameters should be carefully selected. Explosives should be matched to the host material and blast geometries properly chosen so that the required fragmentation results are achieved at optimum costs. Special attention must be directed to selecting blast parameters that produce uniform bed permeability, suppression of fines, proper fragment size distribution, and minimal damage to the retort walls and ceiling. The influence of joints and natural fractures should also be known. In instances where the requisite blasting parameters are unknown, they should be determined from test blasts. Small and intermediate size cratering and bench blast experiments are being made to determine critical depths, volume crater constants, and fragment-size distribution scaling constants for Piceance Creek Basin oil shale. The small tests are made using PETN explosive in meter-sized blocks. The intermediate-sized tests are on the ten-to-twenty foot scale using an ANFO explosive. The experiments are designed to investigate the adequacy of using empirical scaling laws to describe the influence of bedding plane orientation, burden distance, explosive energy release, and borehole diameter on blast results. Crater volumes, sieved fragment-size distributions, free surface velocities, and explosive detonation velocities are measured. Data are treated using a Livingston type performance evaluation based on explosive volume to determine critical and optimum depths. Measured fragment-size distributions are interpreted using empirical scaling techniques.

170 (LBL--9040) CONTROL STRATEGIES FOR ABANDONED IN SITU OIL SHALE RETORTS. Persoff, P.; Fox, J.P. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). 1979. Contract W-7405-ENG-48. 10p. (CONF-790440--3). Dep. NTIS, PC A02/MF A01.

From 12. oil shale symposium; Golden, CO, USA (18 Apr 1979).

In situ oil shale retorting may result in a number of environmental impacts including degradation of local surface and groundwaters, low resource recovery, and subsidence. The target of present oil shale commercialization activities is the Mahogany zone in Colorado's Piceance Creek Basin. The principal oil shale resource in this area is surrounded by two confined aquifers. During mining and retorting, these aquifers are dewatered. When the site is abandoned, groundwater will reinvade the area and flow through the abandoned retorts, leaching potentially toxic or carcinogenic materials from the spent oil shale. This material may then be transported in local aquifers, withdrawn in wells or discharged into the Colorado River system as base flow. Certain control technologies appear potentially able to protect groundwater quality at reasonable cost. These include designing retort blocks to include a hydraulic bypass around abandoned retorts (about $0.50/bbl), placing absorbent clays in abandoned retorts to catch and hold leachable matter (about $0.50/bbl), collecting leachate and treating it on the surface (about $1.20/bbl), protecting abandoned retorts from leaching by placing a grout curtain around a block of abandoned retorts (about $2.00 to $3.00/bbl), or grouting abandoned retorts with spent shale (about $3 to $4/bbl).

171 (LETC/RI--79/6) INTEGRATED COMPLIANCE AND CONTROL TECHNOLOGY RESEARCH ACTIVITIES FOR IN SITU FOSSIL FUEL PROCESSING EXPERIMENTS. Farrier, D.S.; Harrington, L.W.; Poulson, R.E. (Department of Energy, Laramie, WY (USA). Laramie Energy Technology Center). Sep 1979. 18p. Dep. NTIS, PC A02/MF A01.

There are federal and state regulations on surface and subsurface water pollution. Emerging in situ fossil fuel technologies must be cognizant of these and develop process water control measures to insure compliance. Compliance with regulations must also be met at federally operated field facilities conducting in situ process development research. At the same time, such field facilities offer prime opportunities for researching, developing, and demonstrating process water control technology applicable to an emerging industry. This paper has illustrated the approach in effect at the Laramie Energy Technology Center to use in house field activities for advancement of process water control technology while insuring compliance with regulations.

172 (LETC/RI--79/7) SIMULATED IN SITU RETORTING OF OIL SHALE IN A CONTROLLED-STATE RETORT. I. NITROGEN ATMOSPHERE, INTERRUPTED RUNS. Duvall, J.J. (Department of Energy, Laramie, WY (USA). Laramie Energy Technology Center). Sep 1979. 64p. Dep. NTIS, PC A04/MF A01.

A series of experiments has been performed on Green River oil shale using the controlled-state retort, an electrically heated retort designed to simulate in situ retorting. Each experiment described was stopped when only part of the shale bed had been completely retorted.

Retorting parameters investigated include heating rate, retorting advance rate, gas input flow rate, and maximum temperature. Oils were washed and bitumens were extracted from the partially retorted and unretorted oil shales. The oils and bitumens were examined by simulated distillation gas chromatography, the product gases were analyzed by mass spectroscopy, and the shales were subjected to elemental analysis. Results of the various analyses are presented and conclusions are drawn from the data concerning the way the product oil moves through the bed of unretorted shale. The effects of temperature, heating rate, gas flow rate, and breadth of retorting zone on oil film thickness and bitumen content; the effect of heating rate on organic carbon content in the retorted shale; and the effect breadth of retorting zone has on the boiling point distribution of oils and bitumens as related to distance from the retorting zone are discussed.

173 (LETC/RI--79/03) SUMMARY OF THE ENVIRONMENTAL MONITORING AT THE ROCK SPRINGS, WYOMING SITE NO. 9, TRUE IN SITU OIL SHALE RETORTING EXPERIMENT. Virgona, J.E.; Poulson, R.E.; Spedding, T.J. (Department of Energy, Laramie, WY (USA). Laramie Energy Technology Center). Jun 1979. 55p. Dep. NTIS, PC A04/MF A01.

The environmental effects and needed control technology associated with the potential in-situ retorting of oil shale in the Green River Basin (near Rock Springs, Wyoming) has been studied for over four years. This environmental monitoring program has included previous and existing in-situ oil-shale retorting field experiments and baseline data collection for potential future retorting experiments. The most extensive environmetal monitoring effort is at Rock Springs Site No. 9, a true in-situ oil-shale retorting field experiment which was ignited April 5, 1976. The purpose of this monitoring program was to identify any significant changes in the hydrology, air quality, and soils. Data have been collected during the pre-operational (baseline) and operational phases and continues to be collected during the post-operational phase. This report presents the results of the environmental monitoring conducted in support of the LETC Rock Springs No. 9 field experiment and the entire DOE oil shale program. 18 figures, 8 tables.

174 (LETC/TPR--78/1) MATHEMATICAL MODEL OF FORWARD COMBUSTION RETORTING OF OIL SHALE. Dockter, L.; Harris, H.G. (Department of Energy, Laramie, WY (USA). Laramie Energy Technology Center). Jul 1978. Contract EX-76-S-01-2234. 24p. Dep. NTIS, PC A02/MF A01.

The first version or ''base model'' is described of a mathematical model of vertical, forward combustion retorting of oil shale that was developed through 1974 at the Laramie Energy Technology Center in Laramie, Wyoming. The model was written to simulate conditions and processes occurring in LETC's experimental batch-type 150-ton retort. Information presented deals with the reasoning and justification for developing the model, a description of the modeling effort, and a comparison of the yields, retorting rates, and other information obtained from the model as compared with actual results from the 150-ton retort. Good qualitative agreement between the ''base model'' and actual experimental results is found. However, quantitative agreement is not realized in this version of the model; some reasons for this are discussed. Current and future work on the model is also discussed.

175 (LLL/TB--005) LLL ENERGY TECHNOLOGIES. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Jun 1978. Contract W-7405-ENG-48. 53p. Dep. NTIS, PC A04/MF A01.

Lawrence Livermore Laboratory (LLL) research programs directed toward recovering and conserving major energy resources are outlined. The research programs are based on the following concepts: (1) Underground Coal Gasification; thick coal beds can be converted underground into a mixture of combustible gases suitable for use as a fuel. (2) Underground Oil Shale Retorting; when oil shale is heated underground to about 400°C, organic material bound in the rock structure decomposes, forming shale oil, a petroleum-like liquid. (3) Gas Stimulation by Massive Hydraulic Fracturing; by fracturing tight underground gas shales and sandstones, great quantities of natural gas can be liberated that would otherwise remain trapped in the rock. (4) Solar Energy; unique solar heat collectors developed at LLL can provide industry with large quantities of hot water and steam at competitive costs. (5) Uranium Resource Survey; LLL is participating in a comprehensive National Uranium Resource Evaluation (NURE). (6) Metal-Air Power Cells for Automobiles; metal-air power cells seem capable of matching the range and performance of internal combustion engines. (7) Fiber-Composite Flywheels for Energy Storage; flywheels made of light, strong, fiber-composite materials could improve the performance of electric cars.

176 (METC/SP--78/6(Vol.1), pp 230-239) IN SINTU PROCESSING OF MICHIGAN ANTRIM: FIELD TESTS. Matthews, R.D.; Humphrey, J.P.; McNamara, P.H.; Kinkel, C.G.; Peil, C.A. (Dow Chemical Co., Midland, MI). Oct 1978.

From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).

The Dow Chemical Company is the prime contractor with DOE in a four-year, $14 million project to assess the feasibility of recovering energy from Antrim oil shale by in situ process. The contract requires that three different fracturing techniques be tried and evaluated in field experiments at the experimental site in Sanilac County, Michigan. The hydrofracturing experiments should be complete by the fall of 1978; chemical underreaming and explosive underreaming experiments are underway. The technique judged most promising of these three in preparing an area for in situ extraction is to be the subject of an ignition attempt. In the first two years, three in situ combustion trials have been made in a group of wells which were drilled by Dow to the DOE contract. During the most recent of these trials, in situ combustion was maintained for a 61-day period while several continuous and cyclic production procedures were tested. Gas having energy values in the target range (150 btu/scf) was produced at various times, although the flow rate at these times was minimal and hence the energy production was low.

177 (METC/SP--79/6, pp 473-483) EFFECTS OF AQUEOUS CARBON DIOXIDE ON DEVONIAN SHALES. Miller, J.F.; Boyer, J.P.; Kent, S.J.; Snyder, M.J.; Sharer, J.C. 1979.

From 3. Eastern gas shales symposium; Morgantown, WV, USA (1 Oct 1979).

The quality and extent of the gas in the thick hydrocarbon-bearing Devonian shales which underlie most of the Eastern US is being investigated by a number of concerns. Although

the gas resource locked in these shales has been variously estimated to be up to three times the current proven gas reserves in this country, the economic feasibility of producing large quantities from this source remains in question due to the fine-grained nature and low permeability of these shales. Because of the nature of these formations, classical hydraulic fracturing to stimulate these sources may result in extensive formation damage. In addition, many of the fractures in these formations appear to have been sealed by deposited salts and carbonates. Because of these factors, enhanced or improved fracturing and stimulation methods are needed. This paper presents progress made to date in a program aimed at the development of information, techniques, and procedures for improved gas or hydraulic fracturing of the tight Devonian shale formations with minimum formation damage. Results are presented which show that the shale is attacked by aqueous CO_2, supercritical CO_2 fluid, and water at typical downhole temperatures and pressures at, or below, lithostatic or fracing pressures, producing fractures, solubilization of a shale material and some increase in permeability to gas flow. 1 figure, 7 tables.

178 (ORO--5197-11) STUDY OF HYDROCARBON--SHALE INTERACTION. PROGRESS REPORT 11, OCTOBER 1--DECEMBER 31, 1978. Schettler, P.D. Jr.; Wampler, D.L. (Juniata Coll., Huntingdon, PA (USA)). 1979. Contract EY-76-S-05-5197. 65p. Dep. NTIS, PC A04/MF A01.

Work was directed at collecting data, building the high pressure isotherm-degasibility apparatus, and modifying the earlier diffusion model for well production to include explicitly the effect of fracture resistance. Four tasks are reported on: high pressure, low pressure data, productivity calculations, and interpretation in terms of other laboratory data. Some of the data are included in this volume, with the remainder appearing in Parts 2 to 5. (DLC)

179 (ORO--5197-11(Pt.2)) STUDY OF HYDROCARBON--SHALE INTERACTION. PROGRESS REPORT 11. PART II. APPENDIX B (CONTINUED). (Juniata Coll., Huntingdon, PA (USA)). 1979. Contract EY-76-S-05-5197. 59p. Dep. NTIS, PC A04/MF A01.

This volume contains pages B61 through B120 of the data summary on shale degasibility. (DLC)

180 (ORO--5197-11(Pt.3)) STUDY OF HYDROCARBON--SHALE INTERACTION. PROGRESS REPORT 11. PART III. APPENDIX B (CONTINUED). (Juniata Coll., Huntingdon, PA (USA)). 1979. Contract EY-76-S-05-5197. 60p. Dep. NTIS, PC A04/MF A01.

This volume contains pages B121 through B180 of the data summary on shale degasibility. (DLC)

181 (ORO--5197-11(Pt.4)) STUDY OF HYDROCARBON--SHALE INTERACTION. PROGRESS REPORT 11. PART IV. APPENDIX B (CONTINUED), APPENDIX C. (Juniata Coll., Huntingdon, PA (USA)). 1979. Contract EY-76-S-05-5197. 66p. Dep. NTIS, PC A04/MF A01.

This volume contains pages B181 through B226 of the data summary on shale degassing, and a two-step model for gas production from low-permeability shales. The model accounts explicitly for both flow of methane through fractures and diffusion through bulk shale to the fractures. Fracture lengths are calculated which are in the order of several kilometers. A single such fracture 0.1 mm wide and intersecting a 40-m length of well bore can account for 50 Mcf/d after 1 year using a specific degasibility of the rock of 4×10^{-7} $cm^3/cm^2/torr/s/sup\ 1/2/$.

182 (ORO--5197-11(Pt.5)) STUDY OF HYDROCARBON--SHALE INTERACTION. PROGRESS REPORT 11. PART V. APPENDIX D, APPENDIX E, APPENDIX F. (Juniata Coll., Huntingdon, PA (USA)). 1979. Contract EY-76-S-05-5197. 55p. Dep. NTIS, PC A04/MF A01.

The three appendices are: correlation of specific degasibilities and isotherm measurements with other data; gas chromatographic analysis of off-gassing from wells WV6-MERC-IX, IL3-EGSP, WV5-EGSP, IN2-EGSP, NY1-EGSP, and WV7-EGSP; and report on effect of water and air on specific degasibilities and isotherm parameters.

183 (ORO--5197-13) STUDY OF HYDROCARBON--SHALE INTERACTION. PROGRESS REPORT 13, JANUARY 1--MARCH 31, 1979. Schettler, P.D. Jr.; Wampler, D.L. (Juniata Coll., Huntingdon, PA (USA)). 1979. Contract EY-76-S-05-5197. 189p. Dep. NTIS, PC A09/MF A01.

Work was effected on all four tasks (high pressure, low pressure data, productivity calculations, interpretation in terms of laboratory data). A correlation was noted between the ^{238}U content of shale samples and specific degasibility. A generalization of all our productivity modeling to date (taking into account fracture and diffusive flow) indicates that flat production curves can be associated with a variety of constrictive effects in the fracture system at or near the well bore. (DLC)

184 (SAN--1787-12) GEOKINETICS GROUP IN SITU SHALE OIL RECOVERY PROJECT. FIRST ANNUAL REPORT. Lekas, M.A. (Geokinetics, Inc., Concord, CA (USA)). Mar 1978. Contract ET-78-C-03-1787. 66p. Dep. NTIS, PC A04/MF A01.

The Geokinetics In Situ Oil Shale Project is a cooperative venture between Geokinetics Inc. and Aminoil USA, acting as The Geokinetics Group, and the U.S. Department of Energy. The project is governed by DOE Contract No. ET-76-A-03-1787 and covers a five year period beginning on November 1, 1976. The primary purpose of the project is to develop a true in situ process for recovering shale oil using a fire front moving in a horizontal direction. The total estimated cost of the five year project is $9,168,600. A brief summary is presented of pre-contract work, and all work completed during the first 14 months of the contract (Nov. 1976 through Dec. 1977). The project is being conducted at a field site located 70 miles south of Vernal, Utah. Because of the remote location of the site, and its poor accessibility over unpaved roads, a fully self-contained field camp was constructed to support the project and provide living quarters for the field crew. Fifteen in situ retorts were constructed, ranging in size from 330 tons to 7200 tons. 7 of these retorts have been burned, and a total of 1800 bbls of shale oil have been recovered. Oil shale thicknesses of 22' and cross sectional areas of 880 square feet have been successfully retorted. The results have been encouraging, and the project will continue to scale up its size of the operation in 1978.

185 (SAN--1787-19) INVESTIGATION OF THE GEOKINETICS HORIZONTAL IN SITU OIL SHALE

RETORTING PROCESS. QUARTERLY REPORT, JULY--SEPTEMBER 1978. Zerga, D.P. (Geokinetics, Inc., Concord, CA (USA)). Nov 1978. Contract ET-78-F-03-1787. 22p. Dep. NTIS, PC A02/MF A01.

Work during the period is reported on site preparation for retort No. 19, drilling and blasting for retorts No. 18 and No. 19, re-entry drilling for retort No. 17, retort preparation for retorts No. 16 and No. 17, and retort burn for retorts No. 15 and No. 16. Other activities involving oil handling are requested along with post-blast coring and environmental research. (JRD)

186 (SAN--1787-19(Rev.)) INVESTIGATION OF THE GEOKINETICS HORIZONTAL IN SITU OIL SHALE RETORTING PROCESS. REVISED QUARTERLY REPORT, JULY--SEPTEMBER, 1978. Zerga, D.P. (Geokinetics, Inc., Concord, CA (USA)). Feb 1979. Contract ET-78-F-03-1787. 54p. Dep. NTIS, PC A04/MF A01.

The following are reported: site preparation, drilling/blasting, reentry drilling, retort preparation, retort burn, oil production/handling, post-blast coring, separate experiments, environmental research, Kampsite, retort number 16 gas composition, water quality data, retort tracer tests, vibration and sound study, and shale oil analysis. (DLC)

187 (SAN--1787-T1) INVESTIGATION OF THE GEOKINETICS HORIZONTAL IN SITU OIL SHALE RETORTING PROCESS. QUARTERLY REPORT, OCTOBER-DECEMBER 1978. Mankowski, S.G. (Geokinetics, Inc., Concord, CA (USA)). Mar 1979. Contract ET-78-F-03-1787. 229p. Dep. NTIS, PC A10/MF A01.

Site preparation, drilling and blasting, and retort preparation and burn are reported. During the quarter, 1,754 bbl of shale oil were sold to DOE and shipped to Anvil Points. The post-blast, pre-burn coring was completed on Retort No. 18. Environmental research (water, air, ecology, etc.) is reported.

188 (SAND--78-1196) OIL SHALE PROGRAMS. NINTH QUARTERLY REPORT, JANUARY 1978--MARCH 1978. Boade, R.R. (ed.) . (Sandia Labs., Albuquerque, NM (USA)). Aug 1978. Contract EY-76-C-04-0789. 48p. Dep. NTIS, PC A03/MF A01.

Three separate programs are being conducted: diagnostic and rock mechanics support for the LERC In Situ Oil Shale Program, advanced instrumentation and field projects for in situ oil shale processing, and in situ oil shale bed preparation study. The effort is directed primarily at in situ processing concepts (both true and modified). Field activities were centered primarily around the Rock Springs Site 12 hydraulic/explosive fracturing experiment, continuing with the assessment of the explosive fracturing phase of the experiment and initiating efforts for the retort phase. Evaluation of four slurry explosives for hydrofracture use was completed. Magnetic pressure-loading experiments were performed to examine the fracture strength in oil shale in the intermediate strain rate regime. Analytical and calculational efforts are also reported. (DLC)

189 (SAND--78-1306) NUMERICAL MODELING OF A TRUE IN SITU OIL SHALE RETORT. Tyner, C.E.; Hommert, P.J. (Sandia Labs., Albuquerque, NM (USA)). Jan 1979. Contract EY-76-C-04-0789. 46p. (CONF-790405--2). Dep. NTIS, PC A03/MF A01.

From AICE meeting; Houston, TX, USA (1 Apr 1979).

A numerical model has been developed to simulate the true in situ retorting process. The retort is assumed to be a low-porosity fractured bed composed of large seams of competent shale separated at intervals by open fractures. Kerogen and carbonate decomposition and char, oil, and gas combustion, as well as other reactions, are considered. In contrast to the results of rubbled-bed models, the retorting of seams thicker than one meter is characterized by incomplete retorting and significant oil combustion (10 to 40% of that retorted). The amount of shale retorted can, however, be maximized by proper control of air and steam injection rates, with the injected gas being optimally 40 to 50% steam. The oil available for recovery from a two meter seam can then be, for example, as high as 50% of Fischer Assay.

190 (SAND--78-1548C) TRUE IN SITU FRACTURING OF OIL SHALE-PRELIMINARY RESULTS. Parrish, R.L.; Turner, T.F.; Stevens, A.L. (Sandia Labs., Albuquerque, NM (USA)). 1978. Contract EY-76-C-04-0789. 2p. (CONF-781105--30). Dep. NTIS, PC A02/MF A01.

From ANS meeting; Washington, DC, USA (12 Nov 1978).

DOE is conducting field research on true in situ fracturing and retorting of oil shale.The oil shale seam is about 40 ft. thick and has 50 to 200 ft. of overburden. This formation is located just west of Rock Springs, Wyoming. Several different sites have been tested in this research effort. Methods for fracturing oil shale under true in situ conditions at the field laboratory include electro-linking, hydraulic fracturing, well-bore explosives, slurried explosives and combinations of the above. One method that showed initial promise was hydraulic fracturing followed by injection and detonation of a slurried explosive in the fracture created. The objective of the fracturing experiment was to produce a distributed fracture network with sufficient porosity, permeability and uniformity for retorting. Three horizontal hydraulic fractures were formed in the shale bed. A slurry explosive was inserted and detonated in two of the three fractures. Post-detonation fracture assessment involved direct coring, well bore logging (including TV and caliper), air acceptance, and tracer flow tests. The results indicate that the stresses were sufficient to cause fracturing but that there was no significant tumbling. The major fractures apparent after detonation of the slurry were in the same positions as the hydraulic fractures. Flow logging showed that most of the air passage through the system was through these fractures. Preliminary modeling of the system shows that the existing fractures should support combustion and that shale will be retorted as much as one meter away from the fractures. Since the fractures are less than two meters apart, retorting should be possible. To test this idea, bench scale tests on blocks of oil shale with small fractures are being performed. A small scale two-hole "burn" will be attempted in late September, followed by a full scale burn of the five spot pattern.

191 (SAND--78-1595) CREATION AND CHARACTERIZATION OF HORIZONTAL HYDRAULIC FRACTURES IN OIL SHALE. Parrish, R.L.; Neel, R.R.; Long, A. (Sandia Labs., Albuquerque, NM (USA); Department of Energy, Laramie, WY (USA). Laramie Energy Technology Center). Apr 1979. Contract EY-76-C-04-0789. 100p. Dep. NTIS, PC A05/MF A01.

Sandia Laboratories, in support of the Department of Energy Laramie Energy Technology Center's in-situ oil shale programs, conducted a true in-situ oil shale experiment to evaluate the porosity and permeability produced by detonating a slurry explosive in one or more previously formed hydraulic fractures. The experiment involved the creation and characterization of three closely spaced horizontal hydraulic fractures, followed by the insertion and detonation of a slurry explosive in two of these fractures. Initial site evaluation, explosive evaluation tests, and numerical analyses provided guidance to the hydrofracturing procedure. Numerous diagnostic and evaluation measurements were made before, during, and after the hydrofracturing process for evaluation of the fractures. The results showed that three closely spaced fractures satisfactory for subsequent explosive fracturing had been created in essentially horizontal planes.

192 (SAND--78-1603C) TRUE IN SITU FRACTURING EXPERIMENT: PRELIMINARY RESULTS. Stevens, A.L.; Parrish, R.L.; Turner, T.F. Jr. (Sandia Labs., Albuquerque, NM (USA); Department of Energy, Laramie, WY (USA). Laramie Energy Technology Center). 1978. Contract EY-76-C-04-0789. 24p. (CONF-781003--5). Dep. NTIS, PC A02/MF A01.

From 53. annual technical conference and exhibition of society of petroleum engineers; Houston, TX, USA (1 Oct 1978).

A true in situ oil shale retort bed preparation experiment has been performed using an explosive slurry inserted and detonated in pre-formed horizontal hydraulic fractures. The objective was to test this method for producing a distributed fracture network with sufficient porosity and permeability for retorting. Numerous diagnostic and evaluation measurements were performed during the course of the experiment for initial site evaluation, hydraulic fracture assessment, explosive insertion and detonation performance, and post-detonation fracture and permeability assessment. Results show an extensive degree of fracturing, however the fracture-induced permeability is essentially limited to the enlarged preformed hydraulic fracture horizons into which the explosive slurry was inserted and detonated.

193 (SAND--78-1818) OIL SHALE PROGRAMS. TENTH QUARTERLY REPORT, APRIL 1978--JUNE 1978. Stevens, A.L. (ed.). (Sandia Labs., Albuquerque, NM (USA)). Apr 1979. Contract EY-76-C-04-0789. 74p. Dep. NTIS, PC A04/MF A01.

Work is being performed under three programs: diagnostic and rock mechanics support for the Laramie In Situ-Oil Shale program, advanced instrumentation and field projects for in-situ oil shale processing, and in-situ oil shale bed preparation study.

194 (SAND--78-1827C) K/SUB IC/ AND J-RESISTANCE CURVE MEASUREMENTS ON NEVADA TUFF. Weisinger, R.; Costin, L.S.; Lutz, T.J. (Sandia Labs., Albuquerque, NM (USA)). 1979. Contract EY-76-C-04-0789. 18p. (CONF-790503--1). Dep. NTIS, PC A02/MF A01.

From Spring meeting of society for experimental stress analysis; San Francisco, CA, USA (20 May 1979).

Linear elastic fracture mechanics and J-integral test methods were used to determine the static fracture behavior of a porous volcanic tuff. Notched and prefatigued specimens of two different sizes were tested in three-point bending. The fracture toughness (K/sub Ic/) and the J-resistance (J versus crack growth) curve for each specimen were determined. The results indicate that there is good agreement between the fracture parameters determined by the two methods; however, there is some dependence of the results on specimen size. Possible reasons for this specimen size dependence are discussed. 4 figures.

195 (SAND--78-1950) IN SITU OIL SHALE BED PREPARATION STUDY. PROGRESS REPORT, FEBRUARY 1976--FEBRUARY 1978. Munson, D.E. (ed.). (Sandia Labs., Albuquerque, NM (USA)). Nov 1978. Contract EY-76-C-04-0789. 184p. Dep. NTIS, PC A09/MF A01.

The technology for in-situ oil shale bed preparation is relatively much less well developed than some other resource recovery technologies that have been pursued for a long period of time. Development of such a technology entirely by trial and error in the field can be extremely expensive. Computer modeling has been used increasingly in connection with a number of difficult problems of this type, and offers the opportunity of assisting and speeding the development of an in-situ technology if oil shale response can be described in a reasonable way. It is the goal of the in-situ oil shale bed preparation study to provide such modeling of the mechanical response and fracture processes of rock, as they apply to rubblization in order to prepare an adequate retort. An integral part of this program is the validation of the resultant computer models against field data from rubblization experiments. A complementary effort is the use of the computer models in guiding the design and interpretation of field events. The initial successful use of computer modeling using patently crude material descriptions is most encouraging. Continuation of the program can expect to see an acceleration in the refinement of the material descriptions as the data which have been collected are assimilated and formalized in mathematical form in the computer models. These in turn will permit increasingly quantitative predictions to be made, allowing computer simulation to play an increasing role in understanding the processes of fracture and in the design of in-situ rubblization processes. The fracture nucleation, growth and coalescence models, in particular, should produce computationally convenient descriptions in the near term in which maximum use can be made of relatively simple laboratory measurements of deformation, strength and toughness.

196 (SAND--78-2162) TRUE IN SITU PROCESSING OF OIL SHALE: AN EVALUATION OF CURRENT BED PREPARATION TECHNOLOGY. Boade, R.R.; Stevens, A.L.; Long, A.; Harak, A.E. (Sandia Labs., Albuquerque, NM (USA)). Mar 1979. Contract EY-76-C-04-0789. 88p. Dep. NTIS, PC A05/MF A01.

Limiting attention only to those cases where significant overburden lift cannot be achieved by use of explosives, i.e., to relatively deep oil shale seams, it was concluded that the two rubblization techniques which essentially constitute the current bed preparation technology, namely, the wellbore springing and hydraulic/explosives fracturing concepts, both have inherent traits which will prevent them from ever becoming useful for practical applications. Difficulties with the wellbore springing concept stem largely from the cylinderical geometry which leads to rapidly attenuating stress waves (hence to comparatively small fractured regions) and to the creation of a residually stressed region

around the explosive cavity that restricts fluid flow and hinders void redistribution efforts. Major problems with the hydraulic/explosive fracturing concept are that many operations cannot be controlled and that regions of enhanced permeability are formed only in the vicinity of explosive-filled hydrofractures. The experimental, theoretical and phenomenological information used in the assessment that led to the above conclusions is discussed in detail in the report. The physical characteristics of a successful bed preparation concept are defined along with recommendations for a research-oriented program which would lead to the development of the technology necessary to achieve a successful true in situ retorting capability.

197 (SAND--78-2367C) OVERVIEW OF IN SITU OIL SHALE TECHNOLOGY AND RECENT ADVANCES IN TRUE IN SITU RETORT MODELING. Tyner, C.E. (Sandia Labs., Albuquerque, NM (USA)). 1979. Contract EY-76-C-04-0789. 11p. (CONF-790803--08). Dep. NTIS, PC A02/MF A01.

From 14. intersociety energy conversion conference; Boston, MA, USA (5 Aug 1979).

Portions of document are illegible.

In view of current liquid fuel shortages, development of the oil shale resources of Colorado, Utah, and Wyoming, estimated to contain more than one trillion barrels of oil equivalent, must be considered. The in situ processing of this resource offers a potentially attractive alternative, both economically and environmentally, to surface processing. True and modified in situ retorting technologies are described and current research in these areas briefly outlined. True in situ and related low-void in situ processes would minimize the mining and materials handling problems associated with other technologies. A comprehensive mathematical model has been developed to describe the retorting process in these beds. Use of the model to investigate the effect of various retort geometries and bed conditions on the oil yield from true in situ and low-void in situ retorts is discussed.

198 (SAND--79-0041C) MATERIAL BALANCE CALCULATIONS FOR TRUE IN-SITU OIL SHALE RETORTING. Hommert, P.J. (Sandia Labs., Albuquerque, NM (USA)). 1979. Contract EY-76-C-04-0789. 16p. (CONF-790440--1). Dep. NTIS, PC A02/MF A01.

From 12. oil shale symposium; Golden, CO, USA (18 Apr 1979).

In an effort to further understand the characteristics of true in situ oil shale retorting, a comprehensive material balance procedure has been developed for this application. In addition to the normal elemental balances, laboratory data for the stoichiometry of oil coking and kerogen decomposition are used. This additional information allows estimates to be made as to the extent of the product loss mechanisms of oil coking and oil combustion. Assumptions are necessary in order to close the balance; thus sensitivity of the results to these assumptions is examined. The procedure has been applied to both the Site 9 and, on a preliminary basis, Site 12 oil shale retorts conducted by the Laramie Energy Technology Center. Results indicate that oil combustion and oil coking are significant loss mechanisms, i.e., on the order of 40 to 60% of oil retorted.

199 (SAND--79-0148) ASSESSMENT OF CURRENT BED PREPARATION CONCEPTS FOR TRUE IN SITU OIL SHALE PROCESSING. Boade, R.R. (Sandia Labs., Albuquerque, NM (USA)). Feb 1979. Contract EY-76-C-04-0789. 32p. Dep. NTIS, PC A03/MF A01.

Field experiments performed during the past decade to develop methods for preparing relatively deep oil shale beds for true in situ processing have in nearly all cases employed either the wellbore springing or hydraulic/explosive fracturing concept to introduce the needed permeability into the normally very tight formation. In no case has more than marginal success been achieved. Recently, a study was performed to examine in a detailed way the physical characteristics of the two bed preparation concepts that have been considered in the prior experimental activities. This study led to the conclusion that both concepts have inherent traits which will prevent them from ever becoming viable for practical applications. An overview of the evaluation study is presented in this document, with emphasis given to salient results, rather than to the data that were available for analysis and to the analysis methods. The present document consists of the visual aids and text of an oral presentation that was given at the Laramie Energy Technology Center in October, 1978. A considerably more detailed description of the evaluation study is given in the following report: R.R. Boade, A.L. Stevens, A. Harak, and A. Long, True In Situ Processing of Oil Shale - An Evaluation of Current Bed Preparation Technology, SAND 78-2126, Sandia Laboratories, Albuquerque, NM (1979).

200 (SAND--79-0158) OIL SHALE PROGRAMS. QUARTERLY REPORT, JULY 1978--SEPTEMBER 1978. Stevens, A.L. (ed.). (Sandia Labs., Albuquerque, NM (USA)). Apr 1979. Contract EY-76-C-04-0789. 30p. Dep. NTIS, PC A03/MF A01.

Work is reported in the following three separate programs: Diagnostics and Rock Mechanics Support for the Laramie In Situ Oil Shale program (Site 12 retorting and fracturing), Advanced Instrumentation and Support Projects for In Situ Oil Shale Processing, and In Situ Oil Shale Bed Preparation. (DLC)

201 (SAND--79-0742) IN-SITU OIL SHALE RETORT; THERMOCOUPLE WELL FAILURE ANALYSIS. Douglas, D.L. (Sandia Labs., Albuquerque, NM (USA)). May 1979. Contract EY-76-C-04-0789. 23p. Dep. NTIS, PC A02/MF A01.

A plain-carbon steel pipe, 3/4-in. diam., was used as a thermocouple well during field tests of in-situ oil-shale retorts near Vernal, Utah. The pipe had nearly completely corroded during service stated to be for long periods of time in the temperature range 1000 to 2000°F. One leg of the chromel--alumel thermocouple, the chromel branch, had corroded, and the Inconel 600 sheath was partially corroded. X-ray energy dispersive analysis in a scanning electron microscope revealed that the steel had oxidized to a mixture of iron oxides and/or iron--calcium silicates. A minor amount of iron sulfide was detected. The insulation of the thermocouple had been infiltrated by either liquid nickel sulfide or a eutectic of Ni_3S_2 and Ni. The corroded chromel wire had been converted to Cr_2O_3 and a nickel sulfide. Intergranular formation of Cr_3S_4 in the exterior of the Inconel 600 sheath was noted also. The observations showed that oxidation was the major cause of failure and was selectively assisted by sulfidation, e.g., the thermocouple. The results are consistent with the known products of in-situ retorting of oil shale. Plain-carbon steel is not an oxidation-resistant material and is not suited for high-temperature use. The extensive oxidation

clearly showed that the steel was used at much too high a temperature (generally not suited for temperatures above about 900°F) for excessive time periods. The highly corrosive atmosphere of the gases produced by the in-situ combustion of shale oil requires a chromium-rich alloy such as ferritic or austentic stainless steels, both of which are considerably more expensive than plain-carbon steel. The only alternative to upgrading the material would be to use an aluminum coating. Various coatings are suggested.

202 (SAND--79-0746C) USE OF ELECTRICAL GEOPHYSICAL TECHNIQUES TO MAP AND MONITOR IN SITU OIL SHALE RECOVERY PROCESSES. Bartel, L.C. (Sandia Labs., Albuquerque, NM (USA)). 1979. Contract EY-76-C-04-0789. 25p. (CONF-790440--2). Dep. NTIS, PC A02/MF A01.
From 12. oil shale symposium; Golden, CO, USA (18 Apr 1979).
The electrical conducting property of the in situ coal gasification and oil shale retort reaction zones forms the basis for using electrical geophysical prospecting techniques to map and monitor these in situ processes. The electrical geophysical techniques include: mise-a-la-masse, Schlumberger, and a borehole electrical survey. The field measurements are supported by extensive model calculation and data reduction efforts. The in situ coal gasification reaction boundaries have been successfully delineated using the mise-a-la-masse technique and a ridge regression data inversion algorithm. The electrically determined boundaries at various times during the process are in very good agreement with bounderies determined from thermal data. These electrical techniques are presently being used to monitor the in situ oil shale retort reaction zone. This retorting experiment is being conducted by the Laramie Energy Technology Center at a site near Rock Springs, WY. Monitoring system design, pretest data, and model calculation results for monitoring the retort will be reported in this paper.

203 (SAND--79-0751) OIL SHALE PROGRAMS. QUARTERLY REPORT, OCTOBER 1978--DECEMBER 1978. Stevens, A.L. (ed.). (Sandia Labs., Albuquerque, NM (USA)). May 1979. Contract EY-76-C-04-0789. 47p. Dep. NTIS, PC A03/MF A01.
Work is being done in three programs: Diagnostics and Rock Mechanics Support for the Laramie In Situ Oil Shale program, Advanced Instrumentation and Field Projects for In Situ Oil Shale Processing, and In Situ Oil Shale Bed Preparation. Progress is reported in each program. (DLC)

204 (SAND--79-1188) OIL SHALE PROGRAMS. THIRTEENTH QUARTERLY REPORT, JANUARY 1979-MARCH 1979. Stevens, A.L. (ed.). (Sandia Labs., Albuquerque, NM (USA)). Jul 1979. Contract EY-76-C-04-0789. 46p. Dep. NTIS, PC A03/MF A01.
Three programs are reported: diagnostics and rock mechanics support for the Laramie In-Situ Oil Shale Program, advanced instrumentation and field projects for in-situ oil shale processing, and in-situ bed preparation study. (DLC)

205 (SAND--79-1789) OIL SHALE PROGRAMS. FOURTEENTH QUARTERLY REPORT, APRIL-JUNE, 1979. Stevens, A.L. (ed.). (Sandia Labs., Albuquerque, NM (USA)). Sep 1979. Contract EY-76-C-04-0789. 38p. Dep. NTIS, PC A03/MF A01.
The work is being performed under three programs: (1) Diagnostics and Rock Mechanics Support for the LETC in-situ Oil Shale Program; (2) Advanced Instrumentation and Field Projects for in-situ Oil Shale Processing; and (3) In-situ Bed Preparation Study. Two unsuccessful attempts were made to ignite and retort the Well 2 to Well W two-well pattern within the main wellborne pattern at Rock Springs Site 12. A third ignition was attempted in Well V which was in a region of more extensively fractured shale; combustion was sustained for about 94 hours. On the Geokinetics Oil Shale Project, the Retort 20 was blasted on April 6, and the explosive rubbling of Retorts 21 and 22 was completed on June 27. Work on the In Situ Retorting Model (Crack Model) included modifications and improvements to the code, use of the code to evaluate various retort designs, and continuation of small scale block retorting studies in the laboratory. The code has been used this quarter to evaluate two retort designs; the study of the effect of borehole spacing on an in situ borehole retort is discussed. Calculations have been conducted to determine the distance (or burden) of an explosive charge from a free face which optimizes the extent of fragmentation; the results show that there is an optimum depth of the explosive below the surface that maximizes the rock removed for a given charge size. Laboratory fragmentation tests indicate that fragment size varies inversely with strain rate with a power law relationship. (DLC)

206 (TID--28582) OCCIDENTAL VERTICAL MODIFIED IN SITU PROCESS FOR THE RECOVERY OF OIL FROM OIL SHALE. PHASE I. QUARTERLY PROGRESS REPORT, FEBRUARY 1--APRIL 30, 1978. Loucks, R.A. (Occidental Oil Shale, Inc., Grand Junction, CO (USA)). May 1978. Contract EY-77-A-04-3873. 123p. Dep. NTIS, PC A06/MF A01.
The major activities at the Logan Wash site during the months of February, March, and April were the pre-blast preparation, the explosive loading, the rubbling, and the post-blast cleanup and construction for Retort 6. At the C-b tract, the major construction activities involved site preparation work, mobilization of equipment and materials of the shaft sinking contractor onto the tract, installation of temporary utilities and facilities for the shaft sinking contractor, and commencement of shaft collaring for the Production Shaft and the Service Shaft. Environmental reports prepared for the Logan Wash site are included. These reports are entitled ''Air Quality Measurements at Logan Wash, Colorado, 30 March 1977 to 26 October 1977,'' ''Hydrology of the Occidental Oil Shale, Inc. D.A. Shale Area,'' and ''Vertebrate Populations at the Occidental Oil Shale, Inc. Logan Wash Site Summer 1977.'' (JRD)

207 (TID--28917) OCCIDENTAL VERTICAL MODIFIED IN SITU PROCESS FOR THE RECOVERY OF OIL FROM OIL SHALE: PHASE I. QUARTERLY PROGRESS REPORT, NOVEMBER 1, 1977--JANUARY 31, 1978. Loucks, R.A. (Occidental Oil Shale, Inc., Grand Junction, CO (USA)). Feb 1978. Contract EF-77-A-04-3873. 396p. Dep. NTIS, PC A17/MF A01.
Work at the D.A. Shale site during this quarter involved mainly the completion of Retort 5 processing, and the mining, drilling, and engineering activities required in the preparation of Retort 6. At the C-b tract, work was begun on the clearance and the surface preparation of the shaft area and the mine support area. Also, site offices were established for the site clearance contractor,

the surveying contractor, and the managing contractor. During the previous two months, bids for the sinking of four shafts on the tract were reviewed, and a contract was awarded in January. The collaring of the first shaft will commence on about February 15.

208 (TID--28943) OCCIDENTAL VERTICAL MODIFIED IN SITU PROCESS FOR THE RECOVERY OF OIL FROM OIL SHALE, PHASE 1. QUARTERLY PROGRESS REPORT, MAY 1--JULY 31, 1978. Loucks, R.A. (Occidental Oil Shale, Inc., Grand Junction, CO (USA)). Aug 1978. Contract EY-77-A-04-3873. 308p. Dep. NTIS, PC A14/MF A01.

Work at Logan Wash during May, June, and July involved post-rubblization construction of Retort 6, flow and tracer testing of the retort, and running a small scale start-up field test to verify the start-up procedure proposed for Retort 6. Ignition is planned for late August 1978. At the C-b tract, the shaft collaring for the production, service and ventilation/escape shafts, the consolidation grouting around the service and production shafts, and excavation of the vertical segment of the service shaft air inlet were completed. Various building and concrete batch plant construction activities continued.

209 (TID--28955) OIL SHALE IN SITU RESEARCH AND DEVELOPMENT. QUARTERLY REPORT NO. 1, AUGUST 1--OCTOBER 31, 1977. Graf, G.L. (Talley Energy Systems, Inc., Scottsdale, AZ (USA)). 1977. Contract ET-77-C-03-1791. 25p. Dep. NTIS, PC A02/MF A01.

The Talley-Frac Retort Site is in Sweetwater County, Wyoming. Work reported includes rock mechanics and fracture, proposed drilling, environmental studies, retort design and evaluation, seismic system, and explosive characterization. (DLC)

210 (TID--28956) OIL SHALE IN SITU RESEARCH AND DEVELOPMENT. QUARTERLY REPORT NO. 2, NOVEMBER 1, 1977-JANUARY 31, 1978. Graf, G.L. (Talley-Frac Corp., Mesa, AZ (USA)). 1978. Contract ET-77-C-03-1791. 107p. Dep. NTIS, PC A06/MF A01.

This program pertains to the Oil Shale Site 12 near Green River, Wyoming. The report includes a narrative report on the in-situ R and D program and on engineering progress on fracture and retort design and evaluation, a survey of the Section 17 in Sweetwater County, an outline of hydrogeological plan, various meetings, proposed hydraulic fracturing program, well logs, work plan and schedule. (DLC)

211 (TID--28958) OIL SHALE IN SITU RESEARCH AND DEVELOPMENT. QUARTERLY REPORT NO. 3, FEBRUARY 1--APRIL 30, 1978. Graf, G.L.; Richardson, W.B.; Morris, J.; Fricke, L. (Talley Energy Systems, Inc., Scottsdale, AZ (USA)). 1978. Contract ET-77-C-03-1791. 75p. Dep. NTIS, PC A04/MF A01.

The in-situ shale oil recovery project is located near Green River, Wyoming. This document relates to site preparation, hydrofracture activity, pre-hydraulic fracturing studies, instrumentation, detonator, coproduced water, and modeling efforts. Well pattern, anomalous water/entrained sand flow, water quality analysis, core description, and coproduced water are also covered in appendices. (DLC)

212 (TID--29381) SIMULTANEOUS MEASUREMENT OF THE THERMAL AND ELECTRICAL CONDUCTIVITY OF GREEN RIVER OIL SHALE. FINAL REPORT, JUNE 2, 1976--AUGUST 30, 1977. DuBow, J. (Colorado State Univ., Fort Collins (USA). Engineering Research Center). 1978. Contract ET-78-S-03-1748. 102p. Dep. NTIS, PC A06/MF A01.

Goal was to investigate the thermal environmental effects of in-situ retorting operations. Conclusion is that the insulating nature of the shale and the surrounding country rock are such as to make the thermal pollution due to in-situ retorting an insignificant environmental hazard. An estimate of minimum pillar thickness for pillar temperatures below 250°C can be made from the calculations. Thermal conductivity of Green River oil shale decreases with temperature, and 30% anisotropy exists parallel and perpendicular to the sedimentary varve lines. 31 figures, 3 tables. (DLC)

213 (UCID--18028) MULTIPHASE FLOW MODELING OF OIL MIST AND LIQUID FILM FORMATION IN OIL SHALE RETORTING. Lyczkowski, R.W.; Gidaspow, D. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 12 Jan 1979. Contract W-7405-ENG-48. 35p. Dep. NTIS, PC A03/MF A01.

A first level model is developed to account for the appearance and disappearance of liquid oil produced during oil shale retorting. Although nearly all the kerogen initially present in the oil shale exits the retort in the form of a liquid either in the form of a mist or a falling film, the flow of this valuable, clean liquid fuel is not presently accounted for in oil shale retorting computer models. A rigorous treatment of the problem is very difficult. A simplified but sophisticated treatment is developed which is designed to be easily incorporated into the LLL computer model now without major modifications to the numerical solution algorithms. A complete set of equations and simple models are developed to explicitly account for the movement of condensed oil mist and liquid film flowing at unequal velocities. The equations clearly illustrate where more detailed treatments may be inserted, as they are developed.

214 (UCRL--13979) PLAN TO DEMONSTRATE OIL SHALE MINING AND RUBBLIZING FOR A MODIFIED IN SITU RETORTING PROCESS. (Golder Associates, Inc., Kirkland, WA (USA)). Jan 1979. Contract W-7405-ENG-48. 50p. Dep. NTIS, PC A03/MF A01.

A proposed program for investigating the mining and rubblizing requirements for modified in-situ retorting is reported. The program includes basic blasting experiments in small scale retorts and is scoped in some detail with schedules and costs estimated fairly reliably. The program also includes application of the results obtained to a larger scale to test the mining concepts and the success of rubblization in a commercial size retort. This work is necessarily described in less detail and only approximate time and cost estimates are provided.

215 (UCRL--52551) LAWRENCE LIVERMORE LABORATORY OIL SHALE RETORTS. Sandholtz, W.A.; Ackerman, F.J.; Rothman, A.J.; Miller, W.C.; Cope, E.; Ronchetto, J. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 18 Sep 1978. Contract W-7405-ENG-48. 30p. Dep. NTIS, PC A03/MF A01.

Two retorts and their supporting systems have been developed at LLL to simulate some aspects of modified in situ retorting of oil shale. This report first describes the retorts,

their gas flow and product collection systems, and their instrumentation and process control. Thereafter, it deals with the preparation and characterization of raw shale rubble for retort experiments. The report continues with a discussion of the single dedicated minicomputer that serves both retorts. The retort computer system is multifunctional, providing data acquisition and storag, process monitoring and control, and data reduction and display. Finally, limited experimental results are presented that demonstrate some capabilities of the retort systems and the retort computer system.

216 (UCRL--80914) RECENT EXPERIMENTAL DEVELOPMENTS IN RETORTING OIL SHALE AT THE LAWRENCE LIVERMORE LABORATORY. Rothman, A.J. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Aug 1978. Contract W-7405-ENG-48. 32p. (CONF-781110--9). Dep. NTIS, PC A03/MF A01.

From 71. meeting of the AICHE; Miami, FL, USA (12 Nov 1978).

The Lawrence Livermore Laboratory is engaged in a program aimed at extraction of oil from oil shale in-situ. The experimental program is briefly described. Retorting results obtained in pilot above-ground retorts are reviewed. Combustion retorting of small (1 to 2 cm) particles of narrow size distribution gives yields near 95% of assay, and appears to be reasonably understood and predictable by model calculations. Results on retorting behavior of non-uniform sized particles are less well understood. Reasons for this behavior are examined, and appears to be related to non-uniform gas flow. The effect of steam on retorting is considered.

217 (UCRL--81619) RESULTS OF COMPUTER SIMULATION OF IN-SITU OIL SHALE RETORTING. Braun, R.L. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 11 Jan 1979. Contract W-7405-ENG-48. 39p. (CONF-790405--7). Dep. NTIS, PC A03/MF A01.

From AICE meeting; Houston, TX, USA (1 Apr 1979).

A mathematical model has been developed for simulating the processes involved in the in-situ retorting of rubblized beds of oil shale. The model is a transient, one-dimensional treatment of a packed-bed reactor. It is based on the thermodynamics and kinetics of the numerous chemical reactions and physical processes that are most important for hot inert-gas retorting and for combustion retorting. The validity of the model is tested by comparison with experimental retort data. The predicted retorting results for conditions of interest to comsercial, modified, in-situ retorting are discussed in detail. The initial shale properties, such as grade, carbonate content, and bed porosity, are shown to have an important bearing on the maximum retort temperature, the rate of retorting, and the oil yield. The input-gas properties, such as composition, flow rate, and temperature, are likewise shown to strongly influence the retorting results. The latter properties, particularly the input-gas composition and flow rate, can readily be changed during the course of the retorting operations and thereby offer a sensitive means of retort control.

218 (UCRL--81717) MULTIPHASE FLOW ANALYSIS OF OIL SHALE RETORTING. Gidaspow, D.; Lyczkowski, R.W. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 18 Sep 1978. Contract W-7405-ENG-48. 22p. (CONF-790423--2). Dep. NTIS, PC A02/MF A01.

From 2. multiphase flow and heat transfer symposium workshop; Miami Beach, FL, USA (16 Apr 1979).

Several multiphase phenomena occur during oil shale retorting. An analysis is presented of two of these processes including condensation of oil shale vapor and oscillations of pressure in oil shale blocks through cracked bedding planes. Energy conservation equations for oil shale retorting, which include the effects associated with condensation of oil, are derived on the basis of two phase flow theory. It is suggested that an effective heat capacity associated with the latent heat of condensation should be included in the modeling of simulated modified in-situ oil shale retorting. A pressure propagation equation for fast transients in oil shale cracks has been derived and examined in view of existing experimental data. For slow processes, a limiting solution for maximum pressure in oil shale rocks has been obtained. Generation of high pressures in rocks by thermal or other means may lead to rock fracture which may be taken advantage of in modified in-situ oil shale processing.

219 (UCRL--81717(Rev.1)) MULTIPHASE FLOW ANALYSIS OF OIL SHALE RETORTING. Gidaspow, D.; Lyczkowski, R.W. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Mar 1979. Contract W-7405-ENG-48. 16p. (CONF-790423--4). Dep. NTIS, PC A02/MF A01.

From 2. multiphase flow and heat transfer symposium workshop; Miami Beach, FL, USA (16 Apr 1979).

Multiphase processes associated with oil shale retorting are analyzed including condensation of oil shale vapor, and pressure oscillations in oil shale blocks through cracked bedding planes. Energy conservation equations for oil shale retorting, which include the effects associated with condensation of oil, are derived on the basis of two-phase flow theory. It is suggested that an effective heat capacity associated with the latent heat of condensation should be included in the modeling of simulated modified in-situ oil shale retorting. A pressure propagation equation for fast transients in oil shale cracks has been derived and examined in view of existing experimental data. For slow processes, a limiting solution for maximum pressure in oil shale rocks has been obtained. Generation of high pressures in rocks by thermal or other means may lead to rock fracture which may be taken advantage of in modified in-situ oil shale processing.

220 (UCRL--81721) OIL YIELD LOSS MECHANISMS IN MODIFIED IN SITU RETORTING OF OIL SHALE: THE CHALLENGE OF EFFICIENTLY RETORTING VERY NON-UNIFORM BEDS OF OIL SHALE RUBBLE. Galloway, T.R. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Jan 1979. Contract W-7405-ENG-48. 80p. (CONF-790405--1). Dep. NTIS, PC A05/MF A01.

From AICE meeting; Houston, TX, USA (1 Apr 1979).

Recent experimental pilot scale retort work has shown significant declines in oil recovery yield as the size of the shale block increases. This paper reviews the present level of understanding of yield losses together with experimental evidence for the key fluid mechanical and heat and mass transfer mechanisms that cause these lower yields. It is found that loss in retort oil yield is dominated by the large blocks in the bed through the flow patterns in the matrix material around the blocks and the thermal transient characteristics within the blocks.

The principle mechanism appears to be burning and cracking of the produced oil in the gas phase near the larger shale blocks. The use of process control methods involving air/steam ratio, total flow, and flow variations coupled with monitored exit gas composition appear feasible.

221 (UCRL--81721(Rev.1)) CHALLENGE OF EFFICIENTLY RETORTING VERY NONUNIFORM BEDS OF OIL SHALE RUBBLE. Galloway, T.R. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 16 Mar 1979. Contract W-7405-ENG-48. 74p. (CONF-790405--9). Dep. NTIS, PC A04/MF A01.

From AICE meeting; Houston, TX, USA (1 Apr 1979).

Recent experimental pilot scale retort work has shown significant declines in oil recovery yield as the size of the shale block increases. Current analyses of the problem are reviewed, together with experimental evidence for the key fluid mechanical, heat transfer and mass transfer processes that cause these lower yields. It is found that loss in retort oil yield is dominated by the flow patterns in the matrix material around the large blocks and by the thermal transient characteristics within the blocks. The principal mechanism appears to be burning and cracking of the produced oil in the gas phase near the larger shale blocks. The use of process control methods involving air/steam ratio, total flow, and flow variations coupled with monitored exit gas composition appears feasible to maximize oil production.

222 (UCRL--81956) MULTI-DIMENSIONAL SIMULATION OF FLOW NONUNIFORMITIES IN FISSURED POROUS MEDIA. Lyczkowski, R.W. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 10 Apr 1979. Contract W-7405-ENG-48. 8p. (CONF-790803--28). Dep. NTIS, PC A02/MF A01.

From 14. intersociety energy conversion conference; Boston, MA, USA (5 Aug 1979).

This paper summarizes simulations of the cold bed flow pattern in the large 0.9144 m (3.0 ft) diameter, 6.096 m (20 ft) long Lawrence Livermore Laboratory oil shale retort for Run L-1 in an attempt to gain an understanding of the macroscopic fluid dynamics. These simulations are part of a building-block program to model the dispersive and coupled fluid flow, heat and mass transfer characteristics of oil shale retorts having extremely wide particle size ranges. Such retorts can be characterized as fissured porous media. A best-estimate simulation is possible for Run L-1 since fairly detailed accounting of large (approximately 0.4 m) block placements and average axial void fraction variations were recorded. Experimental traveling centerline thermocouple response curves are interpreted using the computed cold bed flow field. Local voidage variations are not generally known in most retorts and so a simple model is developed to account for the stochastic nature of the problem. Simple analytical solutions and independent computations are used to check the potential reality of the simulations.

223 (UCRL--82077) LLL PROGRESS TOWARD PROCESS CONTROL OF COMMERCIAL MODIFIED IN-SITU RETORT OPERATIONS FOR HIGH YIELD. Galloway, T.R. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 17 Jul 1979. Contract W-7405-ENG-48. 15p. (CONF-790440--5). Dep. NTIS, PC A02/MF A01.

From 12. oil shale symposium; Golden, CO, USA (18 Apr 1979).

Recent results from experiments on the LLL 1/8-and 6-Mg pilot-scale oil-shale retorts have provided new insight into the key oil-loss mechanisms and have suggested a number of practical process-control means for maximizing in situ retort yields. Steam or water mist, total flow, and oxygen flux are valuable process handles in controlling the maximum bed temperatures below 950°C. Shale beds containing a broad size range (i.e., 30-cm to 10--m particles) were found to retort with lower yields than beds with smaller particles in narrow size ranges. The lower yield is dominated by the larger shale blocks through coking and cracking within the block and oxidation and cracking of the oil vapor released outside the block. The oxidation loss results from nonuniform flow that lets oxygen penetrate into the retorting zone. Oxidation and cracking outside blocks appeared to be the dominant loss mechanisms. These may possible be controlled by adding steam, water mist, or recycled exhaust gases to the input air. Process control concepts such as stepwise inert-gas injection and thermal-conduction calming are also discussed. Amont the process indicators considered are low-molecular-weight gases, alkene/alkane ratios, and the roughness (i.e., peaks) of the retorting or steam front. 15 figures.

224 (UCRL--82086) STUDIES OF IGNITION OF IN SITU OIL-SHALE RETORTS WITH HOT INERT GAS. Carley, J.F.; Braun, R.L. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Apr 1979. Contract W-7405-ENG-48. 21p. (CONF-790803--30). Dep. NTIS, PC A02/MF A01.

From 14. intersociety energy conversion conference; Boston, MA, USA (5 Aug 1979).

Preheating with hot, inert gas appears to be a promising method to prepare modified-in-situ oil-shale retorts for ignition. Computer simulation was used to determine the effects of four factors on preheating time, on retorting rate and peak temperatures reached after changeover, and the bank of char generated in the topmost layers of the rubble. The factors are: grade of shale, void fraction of rubble, particle size, and composition of retort gas (percent of air in air/steam mixture). Maximum gas temperature rose sharply with grade and percent air, weakly with particle size; char bank rose with grade and volume fraction of solids, as expected; retorting rate rose most strongly with percent air and void fraction, while preheating time decreased with increasing void fraction and grade. Simple empirical equations provide excellent fits to the results of the complex model calculations over the practical range of the factors.

225 (UCRL--82132) COMPARISON OF FLOW NONUNIFORMITIES IN OIL SHALE PILOT RETORTS WITH THOSE PREDICTED BY NUMERICAL FLOW SIMULATIONS. Galloway, T.R.; Sandholtz, W.A. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 20 Mar 1979. Contract W-7405-ENG-48. 11p. (CONF-790803--5). Dep. NTIS, PC A02/MF A01.

From 14. intersociety energy conversion conference; Boston, MA, USA (5 Aug 1979).

The primary obstacle to commercial recovery of shale oil is the presence of flow nonuniformities in in situ oil shale retorts. In an effort to evaluate the causes of these nonuniformities, we have compared flow data from an experimental retort with computer flow simulations. We found that in areas where the large-scale sweep efficiency was adequate, local nonuniform flow was caused by (a) channeling in regions of high permeability (i.e., along the retort wall and around larger blocks), (b) accelerations in flow around cross-

section blockages, and (c) exothermic chemical reactions that change the gas viscosity.

226 (UCRL--82309) MULTIPHASE FLOW MODELING OF OIL MIST AND LIQUID FILM FORMATION IN OIL SHALE RETORTING. Lyczkowski, R.W.; Gidaspow, D. (California Univ., Livermore (USA). Lawrence Livermore Lab.; Illinois Inst. of Tech., Chicago (USA)). Mar 1979. Contract W-7405-ENG-48. 28p. (CONF-790423--8). Dep. NTIS, PC A03/MF A01.

From 2. multiphase flow and heat transfer symposium workshop; Miami Beach, FL, USA (16 Apr 1979).

A first level model is presented to account for the appearance and disappearance of liquid oil produced during oil shale retorting. Although a substantial fraction of the kerogen initially present in the oil shale exits the retort as a liquid either in the form of a mist or a falling film, the flow or this valuable, clean liquid fuel is not presently accounted for in oil shale retorting computer models. A rigorous treatment of the problem is very difficult. A simplified and tractable treatment is developed which is designed to be incorporated into computer models of the oil shale retorting process. A complete set of equations and simple models are developed to explicitly account for the movement of condensed oil mist and liquid film flowing at unequal velocities. The equations clearly illustrate where more detailed treatments may be inserted, as they are developed.

227 (UCRL--83348) IN SITU OIL SHALE RETORTS: COUPLING OF HEAT AND MASS TRANSFER. Galloway, T.R.; Sandholtz, W.A. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Sep 1979. Contract W-7405-ENG-48. 19p. (CONF-791108--5). Dep. NTIS, PC A02/MF A01.

From 72. AICHE meeting; San Francisco, CA, USA (25 Nov 1979).

The coupling between energy and mass transport has been used to develop a diagnostic method, Thermal Logging, which provides dispersion information and indications of the bed structural character in pilot scale retorts simulating in-situ oil shale rubble beds. This information as to the location and magnitude of flow nonuniformities permits real-time applications of process control techniques to maximize oil production. This paper examines the Thermal Logging process and how it responds to local variations in rubble bed permeability and thermal properties. An analytical relationship is proposed describing the propagation of the thermal logging front and the retorting front and results compared with experimental data from LLL 1/8 and 6 Mg pilot retorts.

228 (UCRL--83568) STUDIES OF OIL-SHALE REACTION CHEMISTRY AT LLL. Burnham, A.K. (California Univ., Livermore (USA). Lawrence Livermore Lat.). 1 Nov 1979. Contract W-7405-ENG-48. 39p. (CONF-791209--1). Dep. NTIS, PC A03/MF A01.

From Institute of Gas Technology symposium; Atlanta, GA, USA (3 Dec 1979).

A review is presented of recent studies on the chemistry of oil shale retorting. Kinetics are summarized for oil production and destruction mechanisms including kerogen-bitumen pyrolysis, oil coking and oil cracking. The effect of retorting conditions on shale oil quality is discussed along with the reverse process of inferring retorting conditions and yield loss mechanisms in modified in-situ retorts. Kinetic studies of carbonate mineral decomposition and related mineral reactions as well as residual carbon gasification are outlined.

229 DETERMINING THE LOCUS OF A PROCESSING ZONE IN AN IN SITU OIL SHALE RETORT. Cha, C.Y.; Bartel, W.J. (to Occidental Oil Shale, Inc.). US Patent 4,163,475. 7 Aug 1979. Filed date 21 Apr 1978. 16p.

A processing zone advances through a fragmented permeable mass of particles containing oil shale in an in-situ oil shale retort in a subterranean formation containing oil shale. The fragmented mass has layers of formation particles of differing composition, such as kerogen content, corresponding to strata of differing composition in the formation. The processing zone advances in a direction substantially perpendicular to such layers in the fragmented mass. Kerogen in oil shale is decomposed to produce gaseous and liquid products including shale oil, and shale oil is withdrawn from the retort. At least one characteristic of the shale oil withdrawn from the retort varies in response to differences in composition of such layers of formation particles through which the processing zone advances. Such a characteristic can be a physical property of the shale oil such as viscosity or specific gravity, or a chemical property such as sulfur content or trace metal content. To determine the locus of the processing zone with respect to such layers in the fragmented mass, formation is analyzed for defining the locus of at least one such layer in the fragmented mass before retorting, and shale oil withdrawn from the retort is monitored for variation of such a characteristic corresponding to advancement of the processing zone through such a layer in the fragmented mass.

230 DETERMINING THE LOCUS OF A PROCESSING ZONE IN AN OIL SHALE RETORT BY MONITORING PRESSURE DROP ACROSS THE RETORT. Cha, C.Y. (to Occidental Oil Shale, Inc.). US Patent 4,162,706. 31 Jul 1979. Filed date 12 Jan 1978. 16p.

A processing zone advances through a fragmented permeable mass of particles containing oil shale in an in-situ oil shale retort in a subterranean formation containing oil shale. The retort has an inlet gas introduced thereto and an effluent gas withdrawn therefrom. To determine the locus of the processing zone, kerogen content of formation at selected locations in the retort is determined before processing the selected locations. Because the difference in pressure between the inlet gas and the effluent gas increases as the kerogen content of formation being processed increases, changes in pressure drop across the fragmented mass can be predicted. By comparing actual changes in pressure drop with predicted change in pressure drop, the locus of the processing zone can be determined.

231 DECREASING HYDROCARBON, HYDROGEN AND CARBON MONOXIDE CONCENTRATION OF A GAS. Cha, C.Y. (to Occidental Oil Shale, Inc.). US Patent 4,156,461. 29 May 1979. Filed date 16 Dec 1977. 12p.

The concentration of hydrocarbons, hydrogen, and carbon monoxide in a gas is reduced by combining these constituents in the gas with oxygen in the presence of a fragmented permeable mass of particles containing oil shale treated to remove organic materials. 1 figure, 1 table.

232 REMOVAL OF PILLARS FROM A VOID FOR EXPLOSIVE EXPANSION TOWARD THE VOID. McCarthy, H.E.; French, G.B. (to Occidental Oil Shale, Inc.). US Patent 4,153,298. 8 May 1979. Filed date 11 Oct 1977. 18p.

A subterranean formation containing oil shale is prepared for in situ retorting by initially excavating at least one void adjacent a zone of unfragmented formation to be expanded. The zone of unfragmented formation has a substantially horizontal free face adjoining the void. At least one support pillar of unfragmented formation is left in the void for supporting overlying formation. Explosive is placed in the zone of unfragmented formation, and in such a support pillar. Explosive in such a pillar and in the zone of unfragmented formation is detonated in a single round of explosions with a time delay between detonation of explosive in such a pillar and detonation of explosive in the zone of unfragmented formation for first expanding such a pillar toward the void and then expanding unfragmented formation toward the void. The time delay is sufficient for creation of free face at the juncture of such a pillar and the zone of unfragmented formation. The time delay is preferably short enough that explosive in the zone of unfragmented formation is detonated before particles formed by explosive expansion of the pillars have come to rest on the floor of the void. The fragmented permeable mass of formation particles so formed in an in situ oil shale retort is then retorted to recover shale oil from oil shale in the fragmented mass.

233 GROUND WATER CONTROL FOR AN IN SITU OIL SHALE RETORT. Ridley, R.D. (to Occidental Oil Shale, Inc.). US Patent 4,153,297. 8 May 1979. Filed date 30 Jun 1977. 12p.

An in situ oil shale retort is formed in a subterranean formation containing oil shale. The retort contains a fragmented permeable mass of particles containing oil shale. An open base of operation is excavated in the formation above the retort site, and an access drift is excavated to the bottom of the retort site. Formation is explosively expanded to form the fragmented mass between the access drift and an elevation spaced below the bottom of the base of operation, leaving a horizontal sill pillar of unfragmented formation between the top of the fragmented mass and the bottom of the base of operation. The sill pillar provides a safe base of operation above the fragmented mass from which to control retorting operations. A plurality of blasting holes used in explosively expanding the formation extend from the base of operation, through the sill pillar, and open into the top of the fragmented mass. Trenches are formed in the base of operation for collecting ground water which enters the base of operation prior to and during retorting operations, and collected ground water is withdrawn from the base of operation. Casings can be placed in the blasting holes and adapted for controlling gas flow through the fragmented mass during retorting operations. The casings extend above the floor of the base of operation to inhibit flow of ground water through the blasting holes into the fragmented mass, and other blasting holes not having such casings are sealed. After retorting is completed, the floor of the base of operation can be covered with a layer of concrete and/or the blasting holes can be sealed with concrete to inhibit leakage of ground water into treated oil shale particles in the fragmented mass.

234 IGNITION OF FRAGMENTED OIL SHALE BELOW A SILL PILLAR IN AN IN SITU OIL SHALE RETORT. Ridley, R.D. (to Occidental Oil Shale, Inc.). US Patent 4,153,110. 8 May 1979. Filed date 13 Jun 1977. 12p.

An in situ oil shale retort is formed in a subterranean formation containing oil shale. The retort contains a fragmented permeable mass of particle containing oil shale. An open base of operation is excavated in the formation above the retort site, and an access drift is excavated to the bottom of the retort site. Formation is explosively expanded to form the fragmented mass in the retort between the access drift and an elevation spaced below the bottom of the base of operation, leaving a horizontal sill pillar of intact formation between the top of the retort and the bottom of the base of operation. The sill pillar has a vertical thickness sufficient to maintain a safe base of operation above the retort after the fragmented mass is formed. Prior to retorting, a particulate combustible material is placed in the blasting holes and ignited, and air is introduced to the ignited particulate combustible material to generate heated ignition gas for heating an upper portion of the fragmented mass below the sill pillar to a temperature greater than the spontaneous ignition temperature of carbonaceous materials in the oil shale. Heated organic carbonaceous material is then contacted with oxygen supplying gas to establish a combustion zone in the fragmented mass. The combustion zone is advanced downwardly through the fragmented mass to provide retorting of particles containing oil shale. Liquid and gaseous products of retorting are withdrawn from the fragmented mass.

235 DETERMINING THE LOCUS OF A RETORTING ZONE IN AN OIL SHALE RETORT BY RATE OF SHALE OIL PRODUCTION. Cha, C.Y.; Bartel, W.J. (to Occidental Oil Shale, Inc.). US Patent 4,150,722. 24 Apr 1979. Filed date 10 Mar 1978. 14p.

A retorting zone advances through a fragmented permeable mass of particles containing oil shale in an in situ oil shale retort in a subterranean formation containing oil shale. The fragmented mass comprises layers of formation particles of differing kerogen content corresponding to strata of differing kerogen content in the subterranean formation. The retorting zone advances in a direction substantially perpendicular to such layers in the fragmented mass. Kerogen in oil shale in the retorting zone is decomposed to produce gaseous and liquid products including shale oil, and shale oil is withdrawn from the fragmented mass. The rate of shale oil production in the retort depends upon the kerogen content of such a layer in such a fragmented mass through which the retorting zone advances. To determine the locus of the retorting zone with respect to such layers in the fragmented mass, formation is assayed for kerogen content for defining the locus of at least one such layer in the fragmented mass before retorting, and the rate of shale oil production from the retort is monitored. The locus of the combustion zone can be estimated from the locus of the retorting zone so determined.

236 METHOD FOR ESTABLISHING A COMBUSTION ZONE IN AN IN SITU OIL SHALE RETORT. Bartel, W.J.; Cha, C.Y.; Burton, R.S. III. (to Occidental Oil Shale, Inc.). US Patent 4,147,389. 3 Apr 1979. Filed date 27 Jun 1977. 14p.

A method for retorting oil shale in an in situ oil shale retort includes the steps of excavating a void in a subterranean formation containing oil shale and placing combustible material in the void adjacent an ignition

situs. Formation is then explosively expanded toward the void to form a retort containing a fragmented permeable mass of formation particles containing oil shale, the top layer of the fragmented mass adjacent an ignition situs containing such combustible material. The combustible material is then ignited for establishing a combustion zone in the retort.

237 METHOD FOR IN SITU RECOVERY OF LIQUID AND GASEOUS PRODUCTS FROM OIL SHALE DEPOSITS. French, G.B. (to Occidental Oil Shale, Inc.). US Patent 4,147,388. 3 Apr 1979. Filed date 5 Jan 1978. 16p.

A tunnel is formed above an in situ oil shale retort in a subterranean deposit containing oil shale. A void is excavated in the retort site, and remaining deposit in the retort site is fragmented by explosively expanding toward the void to form a subterranean cavity containing a fragmented permeable mass of particles containing oil shale. The top of the fragmented mass is spaced downwardly from the tunnel to leave therebetween a pillar of unfragmented deposit. A retorting gas is introduced into the retort through a plurality of sloping passages from the tunnel for retorting oil shale in the fragmented mass. The liquid and gaseous products of such retorting are removed from the bottom of the retort. A portion of the carbonaceous products are used for generating electricity. In working a large area of deposit, a plurality of retorts are arranged in rows and columns. The tunnel is part of a tunnel system communicating with the tops of the retorts and having a peripheral double entry tunnel surrounding the rows and columns of retorts. Tunnel systems are also provided at a level adjacent the bottom of the retorts and at a level between the bottom and top.

238 METHOD FOR IN SITU HEAT PROCESSING OF HYDROCARBONACEOUS FORMATIONS. Bridges, J.; Taflove, A.; Snow, R. (to IIT Research Inst.). US Patent 4,140,180. 20 Feb 1979. Filed date 29 Aug 1977. 24p.

The disclosure describes a technique for uniform heating of relatively large blocks of hydrocarbonaceous formations in situ using radio frequency (RF) electrical energy that is substantially confined to the volume to be heated and effects dielectric heating of the formations. An important aspect of the disclosure relates to the fact that certain hydrocarbonaceous earth formations, for example raw unheated oil shale, exhibit dielectric absorption characteristics in the radio frequency range. In accordance with the system of the invention, a plurality of conductors are inserted in the formations and bound a particular volume of the formations. The phrase bounding a particular volume is intended to mean that the volume is enclosed on at least two sides thereof. Electrical excitation is provided for establishing alternating electric fields in the volume. The frequency of the excitation is selected as a function of the dimensions of the volume so as to establish a substantially nonradiating electric field which is substantially confined in the volume. In this manner, volumetric dielectric heating of the formations will occur to effect approximately uniform controlled heating of the volume.

239 GAS WITHDRAWAL FROM AN IN SITU OIL SHALE RETORT. Mills, E.A. (to Occidental Oil Shale, Inc.). US Patent 4,140,343. 20 Feb 1979. Filed date 14 Feb 1977. 20p. PAT-APPL-768,580.

Liquid and gaseous products are recovered from oil shale in an in situ oil shale retort containing a fragmented permeable mass of particles containing oil shale by retorting oil shale in the fragmented mass to produce gaseous and liquid products. The liquid products are withdrawn from the retort to a first level in unfragmented formation below the elevation of the bottom boundary of the retort. Gaseous products are withdrawn from the retort to a second level below the elevation of the first level.

240 CONTACTING TREATED OIL SHALE WITH CARBON DIOXIDE TO INHIBIT LEACHING. Stewart, R.D. (to Occidental Oil Shale, Inc.). US Patent 4,133,381. 9 Jan 1979. Filed date 27 Dec 1977. 12p.

Leaching of water-soluble constituents from particles containing treated oil shale and including oxides of alkaline earth metals, such as particles in an in situ oil shale retort, is inhibited by contacting the particles with carbon dioxide in the presence of water for a sufficient time to produce a substantially water-insoluble and/or impermeable barrier of carbonates of alkaline earth metals at the surface of the particles.

241 ESTABLISHING A COMBUSTION ZONE BELOW A SILL PILLAR IN AN IN SITU OIL SHALE RETORT. Burton, R.S. III; Chambers, C.C.; Hughes, R.F. (to Occidental Oil Sahle). US Patent 4,133,380. 9 Jan 1979. Filed date 12 Jul 1977. 12p.

An in situ oil shale retort is formed in a subterranean formation containing oil shale. The retort contains a fragmented permeable mass of particles containing oil shale. An open base of operation is excavated in the formation above the retort site, and an access drift is excavated to the bottom of the retort site. Formation is explosively expanded to form the fragmented mass between the access drift and an elevation spaced below the bottom of the base of operation, leaving a horizontal sill pillar of unfragmented formation between the top of the fragmented mass and the bottom of the base of operation. The sill pillar provides a safe base of operation above the fragmented mass after it is formed. The fragmented mass is formed by, among other steps, drilling blasting holes from the base of operation down through the sill pillar and detonating explosive in the holes to form the fragmented mass of particles in the retort below the sill pillar. The fragmented mass is ignited through at least a first one of such blasting holes to establish a combustion zone in the top of the fragmented mass. The combustion zone is then advanced across the top of the fragmented mass by generating a gas pressure differential between the first blasting hole and at least a second blasting hole to draw gas down through the first blasting hole, across a top portion of the fragmented mass, and up through a second blasting hole so that gas flow across an upper portion of the fragmented mass spreads the combustion zone across the fragmented mass.

242 ISOLATION OF IN SITU OIL SHALE RETORTS. French, G.B. (to Occidental Oil Shale). US Patent 4,133,580. 9 Jan 1979. Filed date 15 Jul 1977. 12p.

A row of horizontally spaced apart in situ oil shale retorts is formed in a subterranean formation containing oil shale. Each row is formed by excavating at least a pair of upper and lower retort access drifts at elevations within the top and bottom boundaries of the retort sites. The access drifts extend through

opposite side boundaries of a plurality of retorts in such row. Each retort is formed by excavating upper and lower horizontal voids at the levels of the upper and lower retort access drifts, respectively, such voids being excavated laterally from the access drift within the side boundaries of the retort sites. Each retort is formed by explosively expanding formation toward the upper and lower voids within the boundaries of the retort site to form a fragmented permeable mass of particles containing oil shale in each retort. Following formation of each retort, the retort access drift on the advancing side of the retort are at least partially sealed, preferably with a mass of formation particles covered by a gas impermeably layer and backfilled with a further mass of formation particles.

243 OIL SHALE RETORTING: A CORRELATION OF SELECTED INFRARED ABSORBANCE BANDS WITH PROCESS HEATING RATES AND OIL YIELD. Evans, R.A.; Campbell, J.H. (Lawrence Livermore Lab, Calif). In Situ; 3: No. 1, 33-51(1979).

The measured absorbance for specific infrared bands of Colorado shale oil is correlated with process oil yield and retorting rate. The results show excellent correlations using bands associated with olefinic groups (910, 990 and 1640 cm;sup -1;); analyses were carried out using both quantitative and qualitative infrared methods. No pretreatment of the crude shale oil is required. The results are encouraging enough that, with further development, the method may have potential use as an ''on-line'' monitoring technique for various retorting processes. 8 refs.

244 ANALYSIS OF TRANSIENT TEMPERATURE DISTRIBUTION IN OIL SHALE DUE TO HEAT SOURCE PROPAGATING IN RETORT. Wilhelm, H.E.; DuBow, J.B.; Hong, S.H. (Department of Electrical Engineering, Colorado State University, Fort Collins, Colorado 80523). J. Appl. Phys.; 49: No. 12, 5768-5773(Dec 1978).

The initial-boundary-value problem for the transient temperature fields in oil shale, which is heated by a propagating combustion flame in an in situ retort chimney, is formulated and solved analytically. The heat source of the flame is represented by a Gaussian distribution, which models the average statistical variations in radial and axial flame extensions, and is assumed to build up to maximum strength in accordance with a temporal relaxation process. The transient temperature fields in the oil shale surrounding the retort are calculated and discussed with respect to their spatial variations and dependence on the flame relaxation time. The theoretical temperature distributions are shown to be consistent with those observed experimentally. The high-temperature core extends less than a retort radius into the surrounding shale bed. This result has implications for (i) the in situ retort design and (ii) the environmental impact of in situ retorts. It appears that the spacing between neighboring retorts can be reduced and that the thermal effects of retorts on the environment are less severe than previously anticipated.

245 METHOD OF ENHANCING YIELD FROM AN IN SITU OIL SHALE RETORT. Cha, C.Y. (to Occidental Oil Shale, Inc.). US Patent 4,126,180. 21 Nov 1978. Filed date 13 Jun 1977. 14p.

To recover liquid and gaseous products from a fragmented permeable mass of particles containing oil shale, a buffer zone containing retorted oil shale is established in the fragmented mass by passing a hot processing gas substantially free of free oxygen through at least a portion of the fragmented mass. Thereafter, a combustion zone is established in the buffer zone, and a combustion zone feed containing oxygen is introduced into the fragmented mass on the trailing side of the combustion zone. This advances the combustion zone through the fragmented mass and retorts oil shale in a retorting zone on the advancing side of the combustion zone. The thickness of the buffer zone is sufficient for reaction of most of the oxygen in the combustion zone feed with residual carbonaceous material in retorted oil shale in the buffer zone.

246 DETERMINING THE LOCUS OF A PROCESSING ZONE IN AN IN SITU OIL SHALE RETORT BY PRESSURE MONITORING. Ridley, R.D.; Burton, R.S. III. (to Occidental Oil Shale, Inc.). US Patent 4,120,354. 17 Oct 1978. Filed date 3 Jun 1977. 14p.

The locus of a processing zone advancing through a fragmented permeable mass of particles in an in situ oil shale retort in a subterranean formation containing oil shale is determined by monitoring pressure in the retort. Monitoring can be effected by placing a pressure transducer in a well extending through the formation adjacent the retort and/or in the fragmented mass such as in a well extending into the fragmented mass.

247 IN SITU OIL SHALE RETORTING PROCESS USING INTRODUCTION OF GAS AT AN INTERMEDIATE LOCATION. Bartel, W.J.; Burton, R.S. III.; Cha, C.Y. (to Occidental Oil Shale, Inc.). US Patent 4,119,345. 10 Oct 1978. Filed date 4 Apr 1977. 10p.

Valves are recovered from a subterranean in-situ oil shale retort containing a fragmented permeable mass of formation particles by passing a measuring gas through the retort to determine the presence of a blockage in the fragmented mass. If there is such a blockage, only a portion of the fragmented mass is processed and the portion of the fragmented mass having the blockage is left unprocessed. This is effected by introducing a processing gas to the retort at an intermediate location between opposing ends of the fragmented mass and withdrawing gaseous and liquid products of processing at an end of the fragmented mass remote from such blockage.

248 TRUE IN-SITU RETORTING OF OIL SHALE. Fricke, L.S. (Talley Energy Systems, Inc., Scottsdale, AZ). Am. Chem. Soc., Div. Pet. Chem., Prepr.; 23: No. 4, 1310-1315(Sep 1978). (CONF-780902--P4).

From American Chemical Society meeting; Miami, FL, USA (10 Sep 1978).

The true in-situ retorting of oil shale, conducted underground, makes complete reclamation of the surface of the ground possible and feasible. Massive movement of ground is not necessary since surface features have remained virtually unchanged and wells are easily covered. In contrast, much movement of rock is required when shale is mined and then the burnt shale returned to the ground. When shale is mined and retorted, the retorting process changes the rock's structure such that a larger than original volume is encompassed by the rock, making complete replacement of the spent shale impossible. The major environmental problem encountered in above ground retorts, the need for large amounts of water during processing, is not encountered in the true in-situ process. On the contrary, the water produced due to the combustion of kerogen and oil and pumped out with the oil at the

production wells becomes a resource when it is separated from the oil and other retort products. At that point the water is suitable for animal use, and has even been considered for use in development of fisheries near the oil shale sites.

249 METHOD OF BREAKING SHALE OIL--WATER EMULSION. Burton, R.S. III. (to Occidental Oil Shale, Inc.). US Patent 4,109,718. 29 Aug 1978. Filed date 1 Nov 1976. 8p.

A technique is described for breaking the very strong emulsion of shale oil and water produced by an in situ oil shale retorting process so that separate shale oil and water phases can be recovered. The emulsion is broken by heating it to a temperature of at least about 120°F and holding at a temperature in the range of from about 120 to 180°F for about one day. Preferably the shale oil and water are held in the range of from about 130 to 150°F for about one day and the phases separated by gravity. Heat for the process can be obtained by injecting water into a spent in situ oil shale retort for generating steam and transferring heat from the steam to the emulsion.

250 METHOD OF FORMING IN SITU OIL SHALE RETORTS. French, G.B. (to Occidental Oil Shale, Inc.). US Patent 4,106,814. 15 Aug 1978. Filed date 15 Jul 1977. 14p.

A row of horizontally spaced apart in situ oil shale retorts is formed in a subterranean formation containing oil shale. Each row is formed by excavating at least a pair of upper and lower retort access drifts at elevations within the top and bottom boundaries of the retort sites. The access drifts extend through opposite side boundaries of a plurality of retorts in such row. Each retort is formed by excavating upper and lower horizontal voids at the levels of the upper and lower right access drifts, respectively, such voids being excavated laterally from the access drift within the side boundaries of the retort sites. Each retort is formed by explosively expanding formation toward the upper and lower voids within the boundaries of the retort site to form a fragmented permeable mass of particles containing oil shale in each retort. Following formation of each retort, the retort access drifts on the advancing side of the retort are at least partially sealed, preferably with a mass of formation particles covered by a gas impermeable layer and backfilled with a further mass of formation particles.

251 PROCESS FOR RECOVERING CARBONACEOUS VALUES FROM POST IN SITU OIL SHALE RETORTING. Cha, C.Y. (to Occidental Oil Shale). US Patent 4,105,072. 8 Aug 1978. Filed date 27 Jan 1977. 22p.

In a process for recovering liquid and gaseous products from an in situ oil shale retort containing a fragmented permeable mass of particles containing oil shale, a heated zone is established in an upper portion of the fragmented mass. For a period of normal retorting operation, an oxygen containing gas is introduced to the fragmented mass on the trailing side of the heated zone at a sufficient rate for advancing the heated zone downwardly through the fragmented mass and liquid products and a relatively lean off gas containing gaseous products are withdrawn from the bottom of the retort. Thereafter, for a period of post-retorting operation, the introduction of gas to the fragmented mass is reduced to a rate such that a relatively rich off gas is withdrawn from the retort. The rich withdrawn off gas preferably has a heating value of at least about 75 Btu/scf. The reduced rate of introduction includes substantial closing of an end of the retort or introduction of gas at a rate less than about 10% of the rate of introduction of gas to the retort during normal retorting operation. Relatively rich off gas from post-retorting operation is preferably withdrawn from the top of the retort and can be used for igniting another retort or for sustaining a secondary combustion zone in a second retort.

252 METHODS FOR MINIMIZING PLASTIC FLOW OF OIL SHALE DURING IN SITU RETORTING. Lewis, A.E.; Mallon, R.G. (to Department of Energy). US Patent 4,096,912. 27 Jun 1978. Filed date 6 Jun 1977. 6p.

PAT-APPL-804,194.

In an in situ oil shale retorting process, plastic flow of hot rubblized oil shale is minimized by injecting carbon dioxide and water into spent shale above the retorting zone. These gases react chemically with the mineral constituents of the spent shale to form a cement-like material which binds the individual shale particles together and bonds the consolidated mass to the wall of the retort. This relieves the weight burden borne by the hot shale below the retorting zone and thereby minimizes plastic flow in the hot shale. At least a portion of the required carbon dioxide and water can be supplied by recycled product gases.

253 REMOVAL OF SULFUR DIOXIDE FROM PROCESS GAS USING TREATED OIL SHALE AND WATER. Ridley, R.D. (to Occidental Oil Shale, Inc.). US Patent 4,093,026. 6 Jun 1978. Filed date 15 Apr 1977. 12p.

Sulfur dioxide is removed from a process gas by passing the process gas through a fragmented permeable mass of particles containing treated oil shale and including alkaline earth oxides. Water in the fragmented mass combines with alkaline earth oxides in the fragmented mass and sulfur dioxide in the process gas with resultant removal of sulfur dioxide from the process gas.

254 LEACHING OF ORGANIC RESIDUALS FROM SIMULATED IN SITU RETORTED OIL SHALE. Amy, G.L. (Univ. of California, Berkeley); Thomas, J.F.; Hines, A.L. Am. Chem. Soc., Div. Fuel Chem., Prepr.; 23: No. 2, 125-133(1978). (CONF-780305--P5).

From American Chemical Society conference; Anaheim, CA, USA (12 Mar 1978).

Based on the results of the preliminary batch experiments, it is apparent that there exists a significant potential for contamination of groundwater by organic residuals leached from in situ spent shale, particularly spent shale produced during inert gas retorting or combustion retorting employing recycle gas. This contamination may preclude certain beneficial uses of groundwater in the immediate vicinity of abandoned in situ retorts. Both the Freundlich and Langmuir equations appear to be fairly appropriate for modelling the leaching of organic material from spent shale samples produced during inert gas retorting.

255 IGNITION OF IN SITU OIL-SHALE RETORTS WITH HOT INERT GAS. Carley, J.F.; Braun, R.L. (Lawrence Livermore Lab., CA). In Situ; 2: No. 4, 271-294(1978).

For controlled-combustion retorting of oil-shale rubble in situ, preheating with hot,

inert gas appears to be a promising method to prepare the rubble for ignition. By thus setting up an initial separation between the combustion and retorting fronts, oil burning should be reduced and temperatures should remain below those at which spent shale fuses. Inert-gas preheating has been investigated by simulation, using the LLL computer model of in situ retorting. The modeling explored the effects of: temperature and flow rate of preheating gas, depth that ignition-range temperatures penetrated before changeover to retorting, temperature at the given depth of changeover, and staged changeover. Several sets of conditions gave retort temperatures below 1000°C with low fuel usage. The choices of preheating factors strongly affect the maximum temperatures reached shortly after changeover. The cost of inert-gas startup appears to be small.

256 OUTLOOK ON OIL SHALE RESEARCH. Weber, J.H. (Laramie Energy Tech. Center, WY). Trans. Am. Nucl. Soc.; 30: 6(1978). (CONF-7811109--).
From 1978 winter meeting of American Nuclear Society; Washington, DC, USA (12 Nov 1978).
OIL SHALES;IN-SITU PROCESSING;IN-SITU RETORTING;RESEARCH PROGRAMS;CHEMICAL PROPERTIES; PHYSICAL PROPERTIES;THERMODYNAMIC PROPERTIES

257 DOE-SPONSORED IN SITU SHALE OIL RECOVERY PROJECTS. Dockter, L.; Harak, A.E. (Laramie Energy Tech. Center, WY). Trans. Am. Nucl. Soc.; 30: 6-7(1978). (CONF-7811109--).
From 1978 winter meeting of American Nuclear Society; Washington, DC, USA (12 Nov 1978).
BLACK SHALES;IN-SITU RETORTING;SHALE OIL; RECOVERY;FIELD TESTS;OIL SHALES

258 SIMULATED IN SITU RETORTING OF MICHIGAN ANTRIM OIL SHALE. Duvall, J.J.; Martel, R.A.; Bartke, T.C. (Laramie Energy Tech. Center, WY). Trans. Am. Nucl. Soc.; 30: 7-8(1978). (CONF-7811109--).
From 1978 winter meeting of American Nuclear Society; Washington, DC, USA (12 Nov 1978).
BLACK SHALES;IN-SITU RETORTING;MICHIGAN;OIL YIELDS

259 TRUE IN SITU FRACTURING OF OIL SHALE: PRELIMINARY RESULTS. Parrish, R.L. (Sandia Labs., Albuquerque, NM); Turner, T.F.; Stevens, A.L. Trans. Am. Nucl. Soc.; 30: 8(1978). (CONF-7811109--).
From 1978 winter meeting of American Nuclear Society; Washington, DC, USA (12 Nov 1978).
OIL SHALES;IN-SITU RETORTING;FRACTURING

260 COMBUSTION RATES FOR OIL SHALE CARBONACEOUS RESIDUE. Dockter, L.; Turner, T.F. (Laramie Energy Research Center, WY). In Situ; 2: No. 3, 197-215(1978).
The combustion rate of the residual carbon remaining in retorted oil shale was investigated using oil shale core samples. Laboratory data indicate the combustion front penetration rate is proportional to the square root of time and increases linearly with the square root of the sweep gas oxygen concentration, implying an ash layer diffusion control mechanism. Equations are presented relating the residual carbon combustion rate to shale richness and the oxygen concentration in the sweep gas.

261 RECOVERY OF LIQUID AND GASEOUS PRODUCTS FROM AN IN SITU OIL SHALE RETORT. French, G.B. (to Occidental Petroleum Corp.). US Patent 4,022,511. 10 May 1977. vp.
Occidental Petroleum Corp.'s new in situ method of retorting oil shale to yield liquid and gaseous products uses a less elaborate approach than conventional ones for cooling the retort off-gases to avoid equipment damage. The in situ oil shale retort has a retort off-gas cooling zone at its product outlet end. The kerogen in the in situ retort is converted to liquid and gaseous products by moving a heated gas through a retorting zone and toward the product outlet end. The movement of gas through the retorting zone is terminated when the retort off-gas moving from the product outlet reaches a temperature above which the hot retort off-gases would delerteriously affect the product collection and removal apparatus in the collection zone adjacent to the outlet. A reduced kerogen content of the oil shale in the retort off-gas cooling zone, as compared with the average kerogen content of oil shale in the in situ retort, improves the yield of products from the retort.

262 ECONOMIC EVALUATION OF COMBINED IN SITU AND SURFACE RETORTING OF OIL SHALE. Grossman, A.P. (TRW, Inc., Redondo Beach, CA). pp 9-15 of Tenth oil shale symposium proceedings. Reubens, J.B. (ed.). Golden, CO; Colorado School of Mines (1977).
From 10. oil shale symposium; Golden, CO, USA (21 Apr 1977).
This study was made to provide Shell Oil Co. with information to aid in their decision whether to continue their investment in the C-b project in Colorado. Occidental anticipates a resource recovery of over 1.6 billion bbl with the combination of in situ and surface retorting, and the return on investment is estimated to be over 15%, basis 100% equity investment. Possible political obstacles are mentioned. 6 figures. (DLC)

263 EVALUATION OF ROCK SPRINGS SITE 9 IN SITU OIL SHALE RETORTING EXPERIMENT. Long, A. Jr.; Merriam, N.W.; Mones, C.G. (Energy Research and Development Administration, Laramie, WY). pp 120-135 of Tenth oil shale symposium proceedings. Reubens, J.B. (ed.). Golden, CO; Colorado School of Mines (1977).
From 10. oil shale symposium; Golden, CO, USA (21 Apr 1977).
Results of the first 150 days of operation of an in situ oil shale retorting experiment near Rock Springs, WY, are presented. Slurry-type explosive was forced into the fractures and detonated to produce a bed of oil shale rubble. The oil shale bed was ignited on April 5, 1976, using an electrical resistance heater to heat air, which was then supplemented with propane in the central injection well. The effects of in situ retorting upon air, ground surface temperature, and ground water were followed. A broad-ranging biochemical study of the effects of retort water on the environment has been initiated. Material balance calculations indicated that 3,260 tons of oil shale were retorted, representing 21% of the oil shale in the target zone. Oil migration beyond the pattern was evident and only 2,483 gallons or 1% of the shale oil resource was recovered. Nitrogen balances showed an average recovery of 93% of injected air. A total calorific value of 1,515 million Btu of gas, averaging 38 Btu/scf, was produced. 7 figures, 13 tables.

264 EXPERIMENTAL WORK ON OIL SHALE AT LAWRENCE LIVERMORE LABORATORY AND PREDICTIONS OF RETORTING CHARACTERISTICS OF OIL SHALES.

Rothman, A.J.; Lewis, A.E. (Univ of Calif, Lawrence Livermore Lab). Isr. J. Technol.; 15: No. 4-5, 273-282(1977).

An experimental program is being carried out to advance oil-shale retorting technology. This paper summarizes some results of laboratory and pilot retorting and gives the reactions of oil-shale char with gases. A computer model of the retorting process has been compared with retort experiments and has been used to predict in situ retorts under various operating conditions. Finally, the results of a retort using Negev (Israel) oil shale are compared with those using Colorado oil shale. Two ''modified in situ'' methods of pyrolyzing kerogen in oil shale are described: ''combustion retorting'' and ''hot gas retorting''. 12 refs.

265 OIL SHALE RETORTING UNDER ADIABATIC CONDITIONS. Mahajan, V.V.; Lumpkin, R.E.; Gragg, F.M.; Fraser, R.J. (Occidental Research Corp., La Verne, CA). pp 191-199 of Tenth oil shale symposium proceedings. Reubens, J.B. (ed.). Golden, CO; Colorado School of Mines (1977).

From 10. oil shale symposium; Golden, CO, USA (21 Apr 1977).

A small pilot plant has been designed and constructed to simulate the retorting of oil shale under conditions pertinent to a modified vertical in-situ shale oil recovery process. The pilot plant consists of a 6-inch diameter (15.2 cm) fixed bed reactor, 4 feet (1.2 m) long with provision for heat supply along the wall. This external heat supply balances the heat losses so that the retort operates like an in-situ retort. Results from typical pilot plant runs are included. These runs are characterized by high oil yields and excellent mass, energy and heat balance closures. 5 figures, 1 table.

266 PARTITIONING OF AS, CD, CU, HG, PB, AND ZN DURING SIMULATED IN-SITU OIL SHALE RETORTING. Fox, J.P. (Univ. of California, Berkeley); McLaughlin, R.D.; Thomas, J.F.; Poluson, R.E. pp 223-237 of Tenth oil shale symposium proceedings. Reubens, J.B. (ed.). Golden, CO; Colorado School of Mines (1977).

From 10. oil shale symposium; Golden, CO, USA (21 Apr 1977).

Effects of retort operating conditions on the volatilization were as follows: the amount of Cd volatilized from the oil shale is a function of temperature. The amount of Hg in the oils is also a function of temperature. The As species present in the gas stream depend on gas composition. No loss of Cu, Pb, or Zn occurs at retorting temperatures studied. 4 tables. (DLC)

267 EXPERIMENTAL WORK ON OIL SHALE AT LAWRENCE LIVERMORE LABORATORY AND PREDICTIONS OF RETORTING CHARACTERISTICS OF OIL SHALES. Rothman, A.J.; Lewis, A.E. (Univ of Calif, Lawrence Livermore Lab). Isr. J. Technol.; 15: No. 4-5, 273-282(1977).

An experimental program is being carried out to advance oil-shale retorting technology. This paper summarizes some results of laboratory and pilot retorting and gives the reactions of oil-shale char with gases. A computer model of the retorting process has been compared with retort experiments and has been used to predict in situ retorts under various operating conditions. Finally, the results of a retort using Negev (Israel) oil shale are compared with those using Colorado oil shale. Two ''modified in situ'' methods of pyrolyzing kerogen in oil shale are described: ''combustion retorting'' and ''hot gas retorting''. 12 refs.

268 FIELD EXPERIMENT OF REVERSE COMBUSTION OIL RECOVERY FROM A UTAH TAR SAND. Land, C.S.; Cuppe, C.Q.; Marchant, L.C.; Carlson, F.M. (Energy Research and Development Administration, Laramie, WY). Interstate Oil Compact Comm. Com. Bull.; 18: No. 2, 53-60(Dec 1976).

A field experiment to recover oil from tar sand by reverse combustion was conducted at Northwest Asphalt Ridge in a 10-foot interval of the Rim Rock sandstone member of the Mesa Verde Formation at a 300-ft depth. Ignition was accomplished November 25, 1975, and the reverse combustion front was propagated successfully through the formation. Results of the field experiment differed significantly from laboratory tests; this is attributed primarily to the extreme heterogeneity of the tar sand formation. Observed temperatures in the burned area were lower than expected, but a large portion of the tar sand within the pattern boundaries was heated to the extent that the bitumen became mobile enough to be produced. After $3^1/_2$ weeks of operation, the project was terminated because of the inability of the surface production equipment to accommodate the heavy hydrocarbons being produced. Although the formation of the cracked products of reverse combustion was less than expected, this recovery process may be used successfully to heat the tar sand reservoir to a temperature high enough that the bitumen becomes mobile enough to be produced. 6 figs, 3 tables.

269 U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION FIELD EXPERIMENT (FOR TAR SAND OIL RECOVERY). Marchant, L.C. Earth Sci. Bull.; 9: No. 2, 1-5(Jun 1976).

E.R.D.A.'s Laramie Energy Research Center is equipping a small-scale field experiment to test the reverse combustion process to recover oil from tar sand. This field experiment, the first of a planned series, will extend the results of laboratory work and will identify the problems that will affect the application of the process in the field. The reverse combustion process will be tested in preference to the alternative forward process, because laboratory experiments have indicated that reduction of permeability downstream from the combustion zone by condensing vapors is not likely to occur. A tar sand section 10 ft thick at the top of the Rim Rock Sandstone has been selected for the experiment. The section has a porosity of about 28.5%, an oil saturation of about 52%, a water saturation of 15.5%, a permeability of 182 mdarcy with the bitumen in place, and a permeability of 615 mdarcy after the oil is extracted. The oil has a gravity of about 10°API and a viscosity of over 500,000 cp at reservoir temperature.

SURFACE METHODS

270 (CONF-7811122--1) IGT HYTORT PROCESS FOR HYDROGEN RETORTING OF DEVONIAN OIL SHALES. Weil, S.A.; Feldkirchner, H.L.; Punwani, D.V.; Janka, J.C. (Institute of Gas Technology, Chicago, IL (USA)). 1978. Contract W-7405-ENG-26. 37p. Dep. NTIS, PC A03/MF A01.

From Chattanooga shale conference; Oak Ridge, TN, USA (14 Nov 1978).

Until recently, many shales were considered unsatisfactory feedstocks because of their relatively low oil yields in the Fischer Assay test and in conventional thermal retorting. In many instances - most notably in the case of

Devonian marine shales of the eastern United States - Fischer Assay oil yields, per unit weight percent of organic shale content, have been less than half of those obtained from the more familiar but less abundant Eocene lacustrine shales of the Green River area of Colorado, Utah, and Wyoming. This strongly suggests that yield differences are related to the chemistry of the specific kerogen being retorted, and in particular to its hydrogen content. IGT work has shown that elemental hydrogen can react with kerogen to enhance the yield of shale oil and hydrocarbon gases obtained by retorting. This work led to the HYTORT concept for the production of syncrude and gas. Utilizing Eastern US Devonian oil shale feedstocks, organic carbon recoveries as high as 90% have been achieved in thermobalance tests, and as high as 85% in bench-scale tests; this compares with a conversion level of only about 35% using eastern shale feedstocks and conventional retorting. Preliminary economic analyses indicate that HYTORT can produce syncrude from low-grade eastern Devonian shales competitively with TOSCO and Paraho processing of higher-grade Colorado shales.

271 (DOE/EV--0044) ENVIRONMENTAL ANALYSIS OF SYNTHETIC LIQUID FUELS. (Department of Energy, Washington, DC (USA)). 12 Jul 1979. 144p. Dep. NTIS, PC A07/MF A01.

Assuming application of the most effective environmental control technolgies and practices, deployment of synthetic liquids facilities on an accelerated schedule to 1990 appears feasible in terms of current environmental constraints. Yet-to-be-defined regulations, in their stringent forms, could change this finding. These regulations include visibility, short-term nitrogen oxide ambient standard, extension of prevention of significant deterioration (PSD) regulations, hazardous waste standards, toxic product regulations, and occupational safety standards. Any production level requires resolution of a number of institutional constraints, including permitting delays and the acceptability of the facility to the local population and state authorities. The greatest impediments for the first-generation technologies include long time delays, facility size limitations, and unwillingness to change the character of the community. There appears to be no absolute environmentally related constraint identified for any of the first-generation surface conversion technologies; second-generation processes run greater risks of major environmental problems. For in situ processes, the major risk is leaching of hazardous materials into water; for direct liquefaction, concern is potential worker and public exposure to toxic substances. Yet-to-be-defined regulations are perceived by developers as major technology development impediments. These include air quality standards (visibility, short-term nitrogen oxide and new PSD regulations), regulation of hazardous wastes and toxic products, underground injection guidelines, and worker safety regulations. Some risk exists that environmental R and D programs cannot fully satisfy all existing and expected regulatory demands, but these risks should be known by 1985 and it is expected that appropriate control adjustments can be made. (LTN)

272 (DOE/EV--0046(Vol.1), pp 308-322) ASSESSMENT OF CONTROL TECHNOLOGY FOR SHALE OIL WASTEWATERS. Mercer, B.W.; Wakamiya, W.; Spencer, R.R.; Mason, M.J. (Battelle Pacific Northwest Labs., Richland, WA). Sep 1979.

From Environmental control symposium; Washington, DC, USA (28 Nov 1978).

Wastewater disposal is an important element to be considered in evaluating the environmental impact of the developing shale oil industry. Wastewater can be generated by a number of different sources within a shale oil recovery facility, depending on the type of recovery system used, the location, and the type of oil shale processed. The pollution potential of the wastewater may be very high as in the case of retort water or it may be low as in the case of some minewaters. Studies have been completed on the evaluation of land disposal and underground injection as disposal options for shale oil wastewaters. Land disposal is the application of wastewater at the soil/air interface to utilize natural chemical and physical reactions for purifying the wastewater. Underground injection makes use of deep confined aquifers or isolated geological zones for discharge of wastewaters. The results of this investigation indicate that both the wastewater characteristics and the climate of the oil shale regions of Colorado, Utah, and Wyoming are not favorable for land disposal of retort water. Underground injection is a viable disposal option for retort water where geological conditions are favorable; however, regulatory restraints are expected to limit the use of this option. Studies are currently in progress on benchscale evaluations of treatment technology for retort water and mine water. Conventional biological treatment appears to be adversely affected by toxicants in the retort water, however, preliminary results indicate that the addition of powdered activated carbon may overcome this problem. Several different methods have been investigated for removal of fluoride, boron, and alkalinity from minewaters. Ion exchange is a leading candidate for treatment of minewaters.

273 (FE--2343-6(Vol.4)) REVIEW AND ANALYSIS OF OIL SHALE TECHNOLOGIES. VOLUME IV. ABOVEGROUND OR SURFACE TECHNOLOGY. Jee, C.K.; White, J.D.; Bhatia, S.K.; Nicholson, D. (Booz-Allen Applied Research, Inc., Bethesda, MD (USA)). Aug 1977. Contract EX-76-C-01-2343. 173p. Dep. NTIS, PC A08/MF A01.

A technical description and evaluation of retorting methods and scale-up scenarios of four representative methods are presented. The methods described and evaluated include the processes developed by the Bureau of Mines (BOM), the Union Oil Company "B," Petrosix, Paraho, TOSCO II, and the Superior Oil Company. For a future economic analysis, scale-up (ranging from 55,000- to 58,000-bbl/day production rate) scenarios are presented for BOM's Gas Combustion retort (GCR), Union "B," Paraho, and TOSCO II retorting processes. In general, the six aboveground processes selected are in an advanced stage of development as compared with in situ processes and several of them are ready for commercial-scale demonstration. There are, however, a few areas that still need further research and development before demonstration can be undertaken. Specific areas of research cannot be defined at this time because process information needed to identify these areas is mostly proprietary. The technical evaluation reveals that the aboveground retorting processes are viable with high scale oil recovery yields. The processes, however, have been tested only at the pilot or semiworks scale and need to be demonstrated on full-scale modules. The scale-up scenarios of the representative processes reveal that the logistics of the mining-to-processing operation will be a major problem at high production rates. For example, a nominal crude shale oil

production rate of about 50,000 bbl/day will require mining at a rate exceeding present large-scale mining rates. The TOSCO II retorting process is the most energy intensive among Paraho, Union "B," and BOM's GCR because of its complexity, which annuls the benefit of less mining. The TOSCO II process, however, is still an attractive process, providing the technique is used with another technique to enhance resource utilization.

274 (FE--2445-1(Vol.1)) WATER RELATED ENVIRONMENTAL EFFECTS IN FUEL CONVERSION. I. SUMMARY VOLUME. Gold, H.; Goldstein, D.J. (Water Purification Associates, Cambridge, MA (USA)). 1978. Contract EX-76-C-01-2445. 259p. Dep. NTIS, PC A12/MF A01.

This report examines some water related effects that could be expected from siting specific conversion plants at given locations in the major coal and oil shale bearing regions of the United States. A total of 90 plant-site combinations were studied: 48 in the Central and Eastern regions and 42 in the Western region. The synthetic fuel technologies examined include: coal gasification to convert coal to pipeline gas; coal liquefaction to convert coal to low sulfur fuel oil; coal refining to produce a de-ashed, low sulfur solvent refined (clean) coal; and oil shale retorting to produce synthetic crude. The results presented include the range of water requirements, the conditions for narrowing the range and optimizing the use of water, the ranges of residual solid wastes, and the cost and energy requirements for wastewater treatment. A comparison of the water requirements with those of two recently published studies shows widely varying estimates and emphasizes the need for both site- and design-specific calculations. A general assessment of the water resources data in the coal and oil shale regions was made. Potential water supply sources for each site were evaluated in terms of the available water supply. The degree of wet cooling used to dissipate waste heat was determined on the basis of water availability and cost.

275 (FE--2445-1(Vol.2)) WATER RELATED ENVIRONMENTAL EFFECTS IN FUEL CONVERSION. II. APPENDIX VOLUME. Gold, H.; Goldstein, D.J. (Water Purification Associates, Cambridge, MA (USA)). 1977. Contract EX-76-C-01-2445. 674p. Dep. NTIS, PC A99/MF A01.

This report examines some water related effects that could be expected from siting specific conversion plants at given locations in the major coal and oil shale bearing regions of the United States. A total of 90 plant-site combinations were studied: 48 in the Central and Eastern regions and 42 in the Western region. The synthetic fuel technologies examined include: coal gasification to convert coal to pipeline gas; coal liquefaction to convert coal to low sulfur fuel oil; coal refining to produce a de-ashed, low sulfur solvent refined (clean) coal; and oil shale retorting to produce synthetic crude. The results presented include the range of water requirements, the conditions for narrowing the range and optimizing the use of water, the ranges of residual solid wastes, and the cost and energy requirements for wastewater treatment. A comparison of the water requirements with those of two recently published studies shows widely varying estimates and emphasizes the need for both site- and design-specific calculations. A general assessment of the water resources data in the coal and oil shale regions was made. Potential water supply sources for each site were evaluated in terms of the available water supply. The degree of wet cooling used to dissipate waste heat was determined on the basis of water availability and cost.

276 (MERC/SP--77/5, pp 734-747) GAS CHROMATOGRAPHIC ANALYSIS OF FISCHER RETORT PRODUCTS OF THE NEW ALBANY SHALE. Rinaldi, G.; Ciccioli, P.; Wimberg, W.B.; Meinschein, W.G. (Univ. of Indiana, Bloomington). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

Samples of the New Albany Shale were heated to various temperatures in the range from 50 to 500°C. The main organic constituents of the oil as well as of the gas phases that were obtained from the heated samples were collected and then characterized and quantified by means of gas chromatography. n-Alkanes were the most abundant compounds in these phases. All possible isomers of alkanes and monoolefinic alkenes are present in C_1 through C_4 products. Branched chain alkanes and steranes were degraded more rapidly than n-alkanes at temperatures between 150° and 300°C. The concentrations of low molecular weight (C_1 to C_4) hydrocarbons increased with sample temperature, but the concentrations of the > C_{17} alkanes were depleted in the heated shale samples relative to the unheated sample. 7 figures.

277 (PNL--2945) SOURCE CHARACTERIZATION STUDIES AT THE PARAHO SEMIWORKS OIL SHALE RETORT. Fruchter, J.S.; Wilkerson, C.L.; Evans, J.C.; Sanders, R.W.; Abel, K.W. (Battelle Pacific Northwest Labs., Richland, WA (USA)). May 1979. Contract EY-76-C-06-1830. 171p. Dep. NTIS, PC A08/MF A01.

In order to determine the redistribution of trace and major elements and species during aboveground oil shale retorting, a comprehensive program was carried out for the sampling and analysis of feedstock, products, effluents, and ambient particulates from the Paraho Semiworks Retort. Samples were obtained during two periods in 1977 when the retort was operating in the direct mode. The data were used to construct mass balances for 31 trace and major elements in various effluents, including the offgas. The computed mass balances indicated that approx. 1% or greater fractions of the As, Co, Hg, N, Ni, S, and Se were released during retorting and redistributed to the product oil, retort water, or product offgas. The fraction released for these seven elements ranged from approx. 1% for Co and Ni to 50 to 60% for Hg and N. Approximately 20% of the S and 5% each of the As and Se were released. Ambient aerosols were found to be elevated near the retorting facility and associated crushing and retorted shale disposal sites. Approximately 50% of these particles were in the respirable range (< 5 μm). The elevated dust loadings are presented very local, as indicated by relatively low aerosol loadings at background sites 100 to 200 m away. State-of-the-art dust control measures were not employed. 15 figures, 19 tables.

278 (TID--28709) LIQUID PHASE DEGRADATION OF SHALE OIL. FINAL REPORT, AUGUST 17, 1976--FEBRUARY 28, 1977. Sohn, H.Y.; Sorensen, N.R.; Jones, M.V. (Energy Research and Development Administration, Laramie, WY (USA). Laramie Energy Research Center). 1977. 38p. Dep. NTIS, PC A03/MF A01.

A study was conducted of the degradation of liquid shale oil to form a carbonaceous solid (char) and low molecular weight hydrocarbon chains which are gaseous at room temperature.

The rates of degradation are characterized by an equation of the form: $R = k_1 + k_2 S$ where S is the concentration of solid shale present in units of (g shale/g oil). The first term represents the homogeneous degradation of shale oil and the second term represents the rate of the heterogeneous degradation due to the interaction between the oil and burnt shale. Several other aspects of the degradation process are discussed. Of particular importance to the true in situ retorting process is the finding that at temperatures above about 400°C, the shale oil undergoes severe degradation by polymerizing into a black char-like substance. This phenomenon requires a detailed further study.

279 (UCID--17849) COMPUTER CODE TO GENERATE CONTOUR PLOTS OF RETORT TEMPERATURE DATA. Ackerman, F.J.; Sherman, N. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Jun 1978. Contract W-7405-ENG-48. 55p. Dep. NTIS, PC A04/MF A01.

Oil shale retorting experiments are being performed in two retorts; a small 125 kg (1' x 5' retort and a large 6 tonne (3' x 20') retort. Temperature data from the retorting experiments is studied in several ways. Detailed measurements of temperature propagation through both retort beds are made by an array of 13 thermocouples on each of two horizontal planes across the bed. The MOVIES code permits visual examination of this data in a time sequence. The code produces a series of three-dimensional contour plots of the temperature data with one or more frames for each time the array data is recorded. Options in the code allow rotation of the image at any time step in order to gain a clearer view of the temperature surface. Some of the features of the code are described and directions for its use are provided.

280 (UCID--17910) OIL SHALE PROJECT SMALL RETORT RUN SUMMARY: RUN S-12. Ackerman, F.J.; Sandholtz, W.A.; Raley, J.H.; Biermann, A.H. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Aug 1978. Contract W-7405-ENG-48. 59p. Dep. NTIS, MF A01.

Portions of document are illegible.

The authors conclude that finely divided shale, broad particle size range, and bed packing characteristics are important factors in retort performance. Future experiments must explore the roles of these factors as they may relate to field operations. The roughness of axial temperature profiles coupled with some localized partial melting observed during inspection of the burned shale bed demonstrates that flow nonuniformities are associated with fine material. Yield loss owing to oil burning could have occurred due to diversion of gas flow by pockets of fines. Oil holdup and subsequent degradation in the fines may have been a factor contributing to the yield loss.

281 (UCID--17934) MODELING OIL PLUGGING AND FLOW NONUNIFORMITIES IN OIL SHALE RETORTS. Lyczkowski, R.W.; Chin, R.C.Y. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 18 Sep 1978. Contract W-7405-ENG-48. 25p. Dep. NTIS, PC A02/MF A01.

Technical approaches are discussed concerning the modeling of two factors that appear to control the recovery of oil in retorts from oil shales having an extremely wide range of particle sizes: oil plugging, i.e., oil mist filtration and clogging of unretorted oil shale and the general aspects of flow nonuniformities. Research is reported devoted to gaining an understanding of the effects of fluid mechanics on the oil shale retorting process and developing sub-models for oil plugging flow nonuniformities and dispersion. The sub-model for oil plugging is used to generate a supplementary set of differential equations and incorporate them into the overall retort model. These equations account for the holdup of liquid oil and its possible coking with subsequent loss in yield. The flow non-uniformity and dispersion sub-models are used to interpret laboratory and field tracer studies to indicate possible flow nonuniformities. It is proposed that these procedures will produce tools which should be useful in interpreting laboratory and field tracer studies. These tools can also be used to perform sensitivity studies. (JRD)

282 (UCID--18068) OIL SHALE PROJECT RUN SUMMARY: SMALL RETORT RUN S-13. Ackerman, F.J.; Sandholtz, W.A.; Raley, J.H.; Tripp, L.J.; Biermann, A. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Jan 1979. Contract W-7405-ENG-48. 65p. Dep. NTIS, PC A04/MF A01.

Retort Run S-13 was a combustion run in the small retort conducted on 28 and 29 September 1977. Anvil Points master bach -2.5 + 1.3 cm material was used with a 50% air and 50% steam mixture. This was the first run using steam as a diluent. The presence of steam markedly increased oxygen efficiency defined as either mass of kerogen processed or mass of oil produced per unit of oxygen consumed (compared with S-11 results). It appears that steam enhanced transport of heat to the retorting zone increased participation of reactions in which steam serves as an oxidant, and lowered endothermicity of mineral decompositions in the presence of added steam. The presence of steam resulted in a gain in total hydrogen production and an increase in the lower heating value of the off-gas (compared with S-11 results). The increased hydrogen did not have a major effect on heating value because the heating value is dominated by the higher hydrocarbons ($> C_3$). It is concluded that steam is potentially beneficial to the retorting process, but further experiments are needed to firmly identify and evaluate the benefits.

283 (UCID--18282) OIL SHALE PROJECT SMALL RETORT RUN SUMMARY, RUN S-15. Ackerman, F.J.; Sandholtz, W.A.; Raley, J.H.; Mallon, R.G.; Carley, J.F.; Tripp, L.J. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Sep 1979. Contract W-7405-ENG-48. 67p. Dep. NTIS, PC A04/MF A01.

Run S-15, the third in a series of steam/air combustion runs, in the 125-kg retort, was identical to Runs S-13 and S-14 in input gas parameters. The principal difference among these runs was the size distribution of the raw shale charge: S-13, -2.5 + 1.3 cm; S-14, -7.6 + 0.001 cm; and S-15, -2.5 + 0.001 cm. Objective was to determine if lower oil yields and the flow nonuniformities evidenced by rough irregular axial temperature profiles in S-14 and L-1 were attributable primarily to the larger particles (+ 2.5 cm). Temperature profiles from previous runs on small uniform shale particles (e.g., S-13) were smooth and regular and oil yields were high (> 90% of Fischer assay). The run was straightforward and ran as predicted. Centerline bed temperatures averaged 1025°C, the highest yet observed in a 125-kg retort run. This produced some wrinkling of the 304 stainless steel retort vessel. Oil yield from S-15 was comparable to that of S-14 (86% vs 88% Fischer assay). The S-15 temperature profiles were as rough as those from S-14. Run S-15 to the conclusion that

fines (< 1.3 cm) also contribute to flow nonuniformities, temperature excursions, and yield loss. One hypothesis is that packed fines with their low permeability (especially if they retain process liquids) divert flows as effectively as blocks. Hydrogen production in S-15, 0.38 wt % of raw shale, was the highest yet observed from LLL retorts. This is attributed mainly to the smaller particle size of the shale charge. Pockets of dark shale (unconsumed char) were observed in the lower portion of the bed when the spent shale was unloaded. Consistent with this was the delay, or even absence, of oxygen appearance in intra-retort gas sampled near these pockets. Thus, nonuniformities in gas flow were particularly evident in these regions.

284 (UCRL-52089(Pt.2)) KINETICS OF DECOMPOSITION OF COLORADO OIL SHALE. II. CARBONATE MINERALS. Campbell, J.H. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 13 Mar 1978. Contract W-7405-ENG-48. 59p. Dep. NTIS, PC A04/MF A01.

The kinetics of decomposition of nahcolite, dawsonite, dolomite, and calcite in oil shale have been investigated using heating rates expected during typical combustion retorting. Furthermore, the rates of decomposition of calcite and dolomite in shale have been studied over a range of heating conditions from 2 to 20°C/min and CO_2 partial pressures of 0 to 1.0 atm. These results lead to the conclusion that, under typical combustion retorting conditions, most of the calcite reacts with SiO_2, rather than decomposing to CaO. Activation energies and preexponential factors characterizing the rate constants for the above reactions are also given; these "engineering" rate data are expressed in a form amenable for use in mathematical models of the retorting process. Also presented are x-ray data on the final product mineral phases in fully burned oil shale. These are found to be mainly members of the akermanite-gehlenite series and diopside. These products are formed from reactions in the solid state of the carbonates and/or their oxides with other minerals in the shale. A summary of enthalpy data for these reactions is given. Finally, the practical implications and limitations of these results for computational and experimental studies of large-scale shale combustion retorting processes are discussed. Included in this discussion are recent results showing the effects of steam on the mineral reactions in shale.

285 (UCRL-81614) REACTION KINETICS BETWEEN STEAM AND OIL SHALE CHAR. Burnham, A.K. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Oct 1978. Contract W-7405-ENG-48. 7p. (CONF-790415--8). Dep. NTIS, PC A02/MF A01.

From 177. national meeting of the American Chemical Society; Honolulu, HI, USA (1 Apr 1979).

The reaction kinetics between steam and the residual organic carbon (char) in retorted Colorado oil shale (Mahogany Zone) were investigated using both isothermal and nonisothermal methods. The reaction is found to depend on the 0.5 power of the steam partial pressure. The steam-char reaction is found to be faster than the CO_2-char reaction at temperatures near 700°C. The reactivity of the char depends on both the heating rate used to generate the char and subsequent thermal treatment. Removal of mineral matter by acid leaching decreases the reactivity of the car by more than an order of magnitude.

286 (UCRL--81622) REACTION KINETICS FOR REMODELING OIL SHALE RETORTING. Campbell, J.H.; Burnham, A.K. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Jan 1979. Contract W-7405-ENG-48. 52p. (CONF-790405--8). Dep. NTIS, PC A04/MF A01.

From AICE meeting; Houston, TX, USA (1 Apr 1979).

Results from recent laboratory kinetic studies at the Lawrence Livermore Laboratory (LLL) on gasification, pyrolysis, and mineral reactions in oil shale are presented. The specific pyrolysis reactions investigated include the decomposition of kerogen, the evolution of oil, hydrogen and C_2 plus C_3 hydrocarbons and the formation of a carbonaceous residue. Data describing the evolution of H_2 and CH_4 during secondary pyrolysis of the carbonaceous residue are also presented. The mineral reaction kinetics discussed include the decomposition and/or reaction (with silica or silicates) of calcite, dolomite, dawsonite and nahcolite. Rate equations describing the effects of CO_2 and steam on the reactions of calcite and dolomite are presented. Finally, kinetics describing gasification of the carbonaceous residue by CO_2 and H_2O are examined. The above kinetic data are summarized in a set of rate expressions that can be used in numerical modeling of oil shale retorting. The rate equations are general enough for modeling both in-situ and surface retorting processes.

287 SHALE RETORTING PROCESS AND APPARATUS. Dhondt, R.D. (to Union Oil Company of California). US Patent 4,162,960. 31 Jul 1979. Filed date 29 Mar 1978. 6p.

Crushed oil shale is segregated into a major portion of relatively large particles and a minor portion of fines which will pass through screen openings up to about 1/4 inch in size. The large particles are subjected to retorting as an upflowing moving bed in countercurrent contact with downflowing hot eduction gas, while the fines are retorted by controlled distribution over the hot upper surface of the bed of retorted large particles.

288 RETORTING OIL SHALE WITH IRON OXIDE IMPREGNATED POROUS PELLETS. Beck, S.R. (to Atlantic Richfield Co.). US Patent 4,158,620. 19 Jun 1979. Filed date 8 Dec 1977. 8p.

Oil shale is mixed and retorted with hot porous pellets. The porous pellets have a surface area of at least 10 square meters per gram. Iron oxide is deposited or impregnated on the pellet surface area prior to retorting. The iron oxide imparts special properties to the pellets. After retorting, the pellets are separated from the processed oil shale solids, reheated and returned to a retort. At least a portion of the pellets are separated by a magnetic separator. 3 claims.

289 HYDROGENATION PROCESS FOR SOLID CARBONACEOUS MATERIALS. Cox, J.L.; Wilcox, W.A. (to Dept. of Energy). US Patent 4,155,832. 22 May 1979. Filed date 23 Dec 1977. 10p.

PAT-APPL-863,765.

Coal or other solid carbonaceous material is contacted with an organic solvent containing both hydrogen and a transition metal catalyst in solution to hydrogenate unsaturated bonds within the carbonaceous material. This benefaction step permits subsequent pyrolysis or hydrogenolysis of the carbonaceous fuel to form gaseous and liquid hydrocarbon products of increased yield and quality.

290 PROCESS FOR RECOVERING AND UPGRADING HYDROCARBONS FROM OIL SHALE. McCollum, J.D.; Quick, L.M. (to Standard Oil Co. (Indiana)). US Patent 4,151,068. 24 Apr 1979. Filed date 8 Jul 1977. 36p.

A process is described for recovering and upgrading hydrocarbons from oil shale by contacting the oil shale solids in the presence of an acidic or oxidative catalytic substance with a water-containing fluid at a temperature in the range of from at least 705°F, the critical temperature of water; to about 900°F, in the absence of externally supplied hydrogen, wherein the water has a density of at least 0.15 gram per milliliter. Examples of such acidic or oxidative catalytic substance are molecular oxygen, sodium bisulfate, sodium bisulfite, and carbon dioxide.

291 FLUIDIZED BED PROCESS FOR RETORTING OIL SHALE. Burton, R.S. III. (to Occidental Oil Shale, Inc.). US Patent 4,148,710. 10 Apr 1979. Filed date 13 Jun 1977. 8p.

Oil shale is pyrolyzed by introducing an oil shale feed to a retorting zone fluidized bed to yeild, as products of retorting, retorted oil shale containing residual carbonaceous material and volatilized hydrocarbons. The retorted oil shale particles are passed to the top of a combustion zone fluidized bed into which a gaseous source of oxygen is introduced for fluidizing the combustion zone fluidized bed and oxidizing residual carbonaceous material contained in the retorted oil shale particles to yield combustion gases for fluidizing the retorting zone fluidized bed and for maintaining the retorting zone fluidized bed at a temperature sufficient to retort oil shale.

292 GASIFICATION PROCESS. Mitchell, D.S.; Sageman, D.R. (to Chevron Research Co.). US Patent 4,137,053. 30 Jan 1979. Filed date 17 Mar 1978. 18p.

A continuous process and apparatus are disclosed for the retorting or gasification of hydrocarbon-containing solids such as oil shale, coal, tar sands, etc., wherein the solids are retorted or gasified in a combined entrained and fluidized bed. A solid fluidized heat-transfer material flows downwardly through a conversion zone. Subdivided hydrocarbon-containing solids are introduced into a central portion of the conversion zone, with smaller particles of the solids being entrained and moving upwardly through the conversion zone countercurrent to the flow of the fluidized heat-transfer material, and larger particles of the solids being fluidized and moving downwardly through the conversion zone concurrent with the flow of the heat-transfer material. A fluidizing gas is injected into a lower portion of the conversion zone and a portion of the solids is combusted, providing the necessary heat for the conversion reactions. Substantially plug flow of the heat-transfer solid and the hydrocarbon-containing solids is maintained by including in the converion zone means for impeding back mixing, such as a packing material filling the conversion zone. (official gogette).

293 IGT HYTORT PROCESS FOR HYDROGEN RETORTING OF DEVONIAN OIL SHALES. Weil, S.A.; Feldkirchner, H.L; Punwani, D.V.; Janka, J.C. Chicago, IL; Institute of Gas Technology (1979). 7p. (CONF-790571--3).

From 6. national conference on energy and the environment; Pittsburgh, PA, USA (21 May 1979).

In the IGT HYTORT Process, Devonian shales are processed at controlled heating rates in an atmosphere of hydrogen at high pressure which can more than double the yields of shale oil and hydrocarbon gases. The resources of Devonian oil shale and the economics of producing synthetic crude oil from them are discussed briefly. (LK)

294 OIL SHALE RETORTING: A CORRELATION OF SELECTED INFRARED ABSORBANCE BANDS WITH PROCESS HEATING RATES AND OIL YEILD. Evans, R.A.; Campbell, J.H. (Lawrence Livermore Lab., CA). In Situ; 3: No. 1, 33-51(1979).

The measured absorbance for specific infrared bands of Colorado shale oil is correlated with process oil yield and retorting rate. The results show excellent correlations using bands associated with olefinic groups (910, 990 and 1640 cm^{-1}); analyses were carried out using both quantitative and qualitative infrared methods. No pretreatment of the crude shale oil is required. The results are encouraging enough that, with further development, the method may have potential use as an on-line monitoring technique for various retorting processes.

295 SPOUTED-BED SHALE RETORTING PROCESS. Tamm, P.W.; Kuehler, C.W. (to Chevron Research Co.). US Patent 4,125,453. 14 Nov 1978. Filed date 10 Mar 1978. 8p.

Disclosed is a process for the retorting of shale and other similar hydrocarbon-containing solids in which the solids to be retorted are mixed with a solid heat-transfer material to provide the necessary heat for retorting. The shale is retorted in a spouted bed of the shale and heat-transfer solids. Preferably, molecular oxygen is excluded from the retorting zone.

296 IMPROVED PROCESS EXTENDS APPLICABILITY FOR EXTRACTING ENERGY FROM SHALE. Ind. Heat. (Pittsburgh); 45: No. 11, 18-19(Nov 1978).

An improved method for extracting a high percentage of useable energy from oil shale has been developed by the Institute of Gas Technology, Chicago, Ill. This second-generation process has also demonstrated a unique flexibility: The product yields can be altered to give mostly oil or mostly substitute natural gas(SNG). The crude shale oil produced by this process is easily pumped. Recent experimental work at IGT has shown that the kerogen in eastern shales can be recovered almost as efficiently as that in western shales by heating the shale in hydrogen through a specific time-temperature cycle. This procedure maximizes recovery of the organic carbon as valuable liquid and gas products.

297 IMPROVED PROCESS EXTENDS APPLICABILITY FOR EXTRACTING ENERGY FROM SHALE. Schora, F.C. Jr. Ind. Heat. (Pittsburgh); 45: No. 11, 18-19(Nov 1978).

The IGT hydroretorting process for processing eastern shales can be modified to optimize the recovery of shale oil or SNG. The process concept is illustrated and environmental impacts of commerical plants estimated. (JSR)

298 INDIRECT HEATING PYROLYSIS OF OIL SHALE. Jones, J.B. Jr.; Reeves, A.A. (to Paraho Corp.). US Patent 4,116,810. 26 Sep 1978. Filed date 24 May 1976. 10p.

Hot, non-oxygenous gas at carefully controlled quantities and at predetermined depths in a bed of lump oil shale provides pyrolysis of the contained kerogen of the oil

shale, and cool non-oxygenous gas is passed up through the bed to conserve the heat inventory for a viable process. The bed, being fed at the top with raw shale and retorted shale being removed at the bottom, provides a constant depth, continuously moving bed of shale, for a continuous process.

299 PROCESS FOR TREATING OIL SHALES. Reed, H.C. (to Kerr-McGee Corp.). US Patent 4,092,237. 30 May 1978. Filed date 13 Jun 1977. 6p.

Oil shale is introduced into a lock which discharges into a closed, vertical, stationary kiln fitted with mechanisms which cause the particulate oil shale to move continuously downwardly in a controlled, uniform plug type flow. The shale is heated by a counter flow of hot, nonoxidizing gases to the temperature required to pyrolyze the kerogen. The gaseous fraction of the kerogen joins the counter flowing gases for removal from the top of the kiln. The hot particulate shale containing the carbonaceous fraction of the kerogen moves downwardly through a second lock into a conveyance connected to the top of a second similar kiln wherein the carbonaceous residue is reacted with gaseous water and oxygen in a cocurrent manner to supply heat to the decarbonized shale and to produce carbon oxides and hydrogen. The heat in the decarbonized shale is then partially removed by a counter flow of a nonoxidizing recycle gas which joins with the carbon oxides and hydrogen to supply heat for retorting in the first kiln. The cooled decarbonized shale passes out of the second kiln through a lock onto a conveyor for disposal.

300 IGT PROCESS IMPROVES SYNFUEL YIELDS FROM EASTERN OIL SHALE. Gas Scope; No. 42, 3-5(Spr 1978).

A hydroretorting process (HYTORT) is being developed that in tests on Devonian shale has given product yields comparable to those from western shale. The process is based on the fact that heating in hydrogen can convert >95% of the organic carbon to useful products. Environmental impact of the process and the size of the eastern shale reserves are discussed. (DLC)

301 CHEMICAL AND PHYSICAL PROPERTIES OF SHALE OIL FROM MICROWAVE HEATING. Damrauer, R.; Wall, E.T.; Lutz, W.; Bies, R.; Cranney, M. (Univ. of Colorado, Denver). Am. Chem. Soc., Div. Pet. Chem., Prepr.; 23: No. 1, 260-261(Feb 1978). (CONF-770814--P2; CONF-780305--P2).

From American Chemical Society meeting; Chicago, IL, USA (29 Aug 1977).

Oil produced by microwave heating is compared with oil obtained by other processes. Preliminary experiments have indicated that oil produced by microwave treatment of oil shale has characteristics suitable for further study. The pouring characteristics are good while other properties are either as good or nearly as good as those of oils from other processes. Attempts will be made in the future to better characterize the oil as to its chemical constituency. In addition experiments will be designed to better understand the interaction of microwave energy with oil shale and to assess the potential for a commercial microwave process.

302 SHALE OIL RETENTION ON CRUSHED UNRETORTED SHALE. Hines, A.L. (Colorado School of Mines, Golden); Duvall, J.J. In Situ; 2: No. 2, 117-126(1978).

The ability to predict the quantity of oil retained on unretorted shale is necessary if viable models of the retorting process are to be formulated. A knowledge of the amount of retained oil is important because a portion of it may be cracked and thus increase the quantity of carbon residue found on the spent shale. Carbon residue not only provides a significant portion of the energy needed to sustain retorting but also plays an important role in the kinetics of the process. In this study, retention data of oil on unretorted shale are presented for shale samples ranging in size from $^1/_2$ inch to number 14 U.S. mesh. The data are correlated in terms of the residual saturation and capillary number.

303 OPTIMIZATION OF OIL SHALE PYROLYSIS. Wen, C.S.; Yen, T.F. (Univ. of Southern California, Los Angeles). Chem. Eng. Sci.; 32: No. 3, 346-349(1977).

A mathematical model was developed which uses the maximum amount of pyrolytic bitumen formation as the optimal object and the temperature as the control variable to perform an optimization of thermal decomposition of kerogen. This establishes an optimal temperature profile for heating time to yield the maximum amount of pyrolytic bitumen. The conditions for optimizing the maximum amount of pyrolytic bitumen were 425°C and a heating time of 10.58 minutes. Since it was shown that all of the kerogen has been converted to pyrolytic products before the concentration of pyrolytic bitumen reached a maximum, the additional heat added could be needed just to convert the pyrolytic bitumen to oil and gas only. From this point, one can calculate and predict the temperature, heating residence time, and thermal requirements for the retorting of shale.

304 EFFECTS OF THERMAL HISTORY ON OIL SHALE PYROLYSIS PRODUCTS. Coomes, R.M.; Sommer, F.H. (Tosco Corp., Golden, CO). pp 200-206 of Tenth oil shale symposium roceedings. Reubens, J.B. (ed.). Golden, CO; Colorado School of Mines (1977).

From 10. oil shale symposium; Golden, CO, USA (21 Apr 1977).

This laboratory study determined the effects of mild thermal treatment of oil shale on quantity and quality of subsequently produced Fischer assay oil. It was determined that heating oil shale, at 70 to 180°C in air, reduced Fischer assay oil yield as much as 58%. Similar thermal histories in oxygen-free atmospheres gave unchanged Fischer assay oil yields. Specific gravity of product shale oil was increased when oil shale was preheated in an oxygen-containing atmosphere. 1 figure, 9 tables.

305 OIL DEGRADATION DURING OIL SHALE RETORTING. Raley, J.H.; Braun, R.L. (Univ. of California, Livermore). Am. Chem. Soc., Div. Fuel Chem., Prepr.; 21: No. 6, 137-146(1976).

Powdered oil shale samples of 22 gal/ton were heated at 12°C/min to a temperature in the 150 to 450°C range, held isothermally for 8, 80, 800 hours, and then heated again at 12°C/min to 500°C. The oil yields relative to assay passed through a minimum of 80 to 92% if the holding temperature was in the 350 to 450°C range. The loss was directly related to the amount of oil produced in the isothermal period and to its residence time in the retort, i.e., the loss was smaller in nitrogen and decreased with increasing nitrogen flow rate. The loss

was thus caused by decomposition of produced oil to char and gas. A kinetic equation for the first order degradation of the oil produced in a first order reaction was developed. The activation energy of degradation was 49.4 kcal/mole. 13 references.

REFINING

306 (FE--2315-25) REFINING AND UPGRADING OF SYNFUELS FROM COAL AND OIL SHALES BY ADVANCED CATALYTIC PROCESSES. FIRST INTERIM REPORT, PROCESSING OF PARAHO SHALE OIL. Sullivan, R.F.; Stangeland, B.E.; Rudy, C.E.; Green, D.C.; Frumkin, H.A. (Chevron Research Co., Richmond, CA (USA)). Apr 1978. Contract EX-76-C-01-2315. 228p. Dep. NTIS, PC A11/MF A01.

Advanced commercial petroleum processing technology was employed in pilot plant facilities to produce transportation fuels (gasoline, kerosene, jet fuel, and diesel) from Paraho shale oil. Three likely refining routes were identified and demonstrated sufficiently to permit preparation of screening-type process designs and cost estimates: (1) hydrotreating followed by hydrocracking, (2) hydrotreating followed by catalytic cracking, and (3) coking followed by hydrotreating. In a fourth feasible alternative, raw shale oil was hydrotreated to produce a synthetic crude suitable for processing in an existing refinery. The key to successful shale oil refining is an effective initial hydrotreating step. This removes contaminants and permits the use of conventional hydrocracking or fluid catalytic cracking. Distillates from coking of raw shale oil also require subsequent hydrotreating to remove residual impurities and meet final product specifications. Refining costs to convert raw shale oil to transportation fuels were estimated to be about $8 to $10/barrel, depending upon the processing route and based on producing 100,000 BPCD of transportation fuels from a grass roots refinery located near a Rocky Mountain or Mid-Continent urban center. Costs are higher for smaller, remotely located refineries. Hydroprocessing of raw shale oil to produce a synthetic crude would cost about $6.50/barrel.

307 (SAND--78-0011C) PARTICLE TRACING TECHNIQUES FOR FLOWS IN POROUS MEDIA. Fox, R.L.; Eaton, R.R.; Krueger, D.A. (Sandia Labs., Albuquerque, NM (USA)). 1978. Contract EY-76-C-04-0789. 8p. (CONF-780711--2). Dep. NTIS, PC A02/MF A01.

From 11. AIAA fluid and plasma dynamics conference; Seattle, WA, USA (10 Jul 1978).

Portions of document are illegible.

The prediction of flow in porous media has been of both current and historical interest. Recent developments, for example, in the in-situ gasification of coal, the removal of hydrocarbons from oil shale, and the extraction of oil and gas require an in-depth understanding of flow in porous geologic media. Existing procedures for investigating these problems require more empirical input than should be necessary if the porous media were adequately described by the computational scheme. The purpose of this paper is to develop a particle tracing scheme for calculating flows in porous media which will reduce the number of required empirical properties, such as permeability, and have application to more general flow regimes such as non-Darcy flows.

308 (UCID--18284) SHALE OIL CRACKING. 1. KINETICS. Burnham, A.K.; Taylor, J.R. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Oct 1979. Contract W-7405-ENG-48. 37p. Dep. NTIS, PC A03/MF A01.

Experiments were conducted to determine kinetics for thermal cracking of shale oil vapor over shale. Cracking temperatures of 504 to 610°C and residence times of 2 to 11 seconds were used. A first-order Arrhenius rate expression and stoichiometry were obtained. Also observed were changes in the oil quality. Cracking decreased the H/C ratio, increased the nitrogen content, and decreased the pour point of the oil. Gas-phase oil cracking is contrasted to liquid-phase oil coking as a loss mechanism in oil-shale retorting.

309 PROCESS FOR THE REMOVAL OF SOLID PARTICULATE MATERIALS FROM CRUDE SHALE OILS. Clapper, T.W. (to Kerr-McGee Corporation). US Patent 4,162,965. 31 Jul 1979. Filed date 7 Jun 1978. 8p.

This invention relates to a process for removing finely divided insoluble particulate materials from crude shale oils. A feed comprising crude shale oil that contains insoluble particulate material is mixed with a solvent and thereafter separated in a first separation zone into a first light fraction comprising the crude shale oil and the solvent and a first heavy fraction comprising the insoluble particulate material, some crude shale oil and some dissolving solvent. The first light fraction then is withdrawn and subjected to a second separation in a second separation zone. In the second separation zone, the first light fraction is separated into a plurality of fractions of crude shale oil and solvent. The crude shale oil fractions then are separated, withdrawn and subjected to subsequent hydrorefining, while the solvent is recovered and recycled to provide additional feed mixture.

310 HYDROPROCESSED SHALE OIL INCLUDING THERMALLY TREATING AND COKING STEPS. Jensen, H.P. (to Chevron Research Co.). US Patent 4,142,961. 6 Mar 1979. Filed date 29 Dec 1977. 10p.

PAT-APPL-865,637.

An arsenic-contaminated shale oil is thermally treated to precipitate the arsenic and to lower the pour point. Treated oil is then transported and thereafter heated to produce coke and a liquid hydrocarbon distillate. At least a portion of the distillate is catalytically processed in the presence of hydrogen, forming a treated shale oil product.

311 CATALYTIC HYDROTREATING PROCESS. Karr, C. Jr.; McCaskill, K.B. (to Dept. of Energy). US Patent 4,128,473. 5 Dec 1978. Filed date 5 Dec 1977. 16p.

PAT-APPL-857,718.

Carbonaceous liquids boiling above about 300°C such as tars, petroleum residuals, shale oils and coal-derived liquids are catalytically hydrotreated by introducing the carbonaceous liquid into a reaction zone at a temperature in the range of 300° to 450°C and a pressure in the range of 300 to 4000 psig for effecting contact between the carbonaceous liquid and a catalytic transition metal sulfide in the reaction zone as a layer on a hydrogen permeable transition metal substrate and then introducing hydrogen into the reaction zone by diffusing the hydrogen through the substrate to effect the hydrogenation of the carbonaceous liquid in the presence of the catalytic sulfide layer. (Official Gazette)

312 STABILIZING OF SHALE OIL--WATER EMULSIONS BY PENTANE-INSOLUBLE MATERIALS. Cottingham, P.L.; Birkholz, F.A.; Nickerson, L.G. (Laramie Energy Research Center, WY). Am. Chem. Soc., Div. Fuel Chem., Prepr.; 23: No. 4, 30-37(1978). (CONF-780902--P2).
From American Chemical Society meeting; Miami, FL, USA (10 Sep 1978).
Pentane-insoluble material from vacuum distillation of in situ crude shale oil, and pentane-insoluble material separated from the crude with a 325-mesh screen were found to be strong emulsifying agents for shale oil/water mixtures. The toluene-soluble and chloroform-soluble portions of pentane-insoluble material separated from the crude with the screen did not promote emulsions when mixed in gas oils at room temperature, but when heated to 320°C for one-half hour with the oil they acted as strong emulsifying agents. It was found that certain parts of the oil have little emulsifying power when mixtures containing them are kept at low temperatures, but display strong emulsifying power when the mixtures are heated to 320°C. This finding suggests the possibility that cooling the freshly-retorted oil as rapidly as possible after it is retorted may be a method of decreasing the formation of emulsions. Several possibilities suggest themselves concerning why the solvent-soluble materials act as emulsifying agents after they have been heated to 320°C in gas oil, but no conclusions have been drawn. These soluble materials were all separated from the insoluble materials by filtration through a fritted-glass funnel during their preparation. This fact is further evidence that a large proportion of the emulsions in shale oil are caused by organic emulsifying agents; however, it does not entirely rule out the possibility that inorganic materials also play a part in the formation of some emulsions. Filtering the raw, wet crude oil through a 325-mesh screen was an effective method of breaking the oil/water emulsion so the water would easily settle out with the application of moderate heat; however, the oil used was over a year old at the time of filtering. The method should be tested on several freshly-retorted crude oils to determine its effectiveness.

313 SYMPOSIUM ON REFINING OF SYNTHETIC CRUDES. Washington, DC; American Chemical Society (1977). 282p. (CONF-770301--P3).
From 173. national meeting of the American Chemical Society; New Orleans, LA, USA (20 Mar 1977).
Selected papers from the symposia on refining of synthetic crudes and recent advances in alkylation were abstracted and prepared for the EDB data base. (JSR)

314 PREPARATION OF SHALE-OIL GASOLINE. Cottingham, P.L. (Energy Research and Development Administration, Laramie, WY). pp 23-30 of Tenth oil shale symposium proceedings. Reubens, J.B. (ed.). Golden, CO; Colorado School of Mines (1977).
From 10. oil shale symposium; Golden, CO, USA (21 Apr 1977).
Shale oil produced from oil shale of the Rocky Mountain region by many of the usual retorting processes consists mainly of high-boiling compounds of nitrogen, sulfur, and oxygen; less than half of the oil consists of hydrocarbons. Gasoline boiling range naphtha has been produced in a yield of 49.6 percent by volume by recycle thermal cracking of the crude. This poor quality naphtha was upgraded by hydrofining and by chemical extraction processes. A higher yield of better-quality naphtha was produced by hydrogenating the crude at 3,000 psig. Hydrogenated naphtha was catalytically reformed to a high-octane product. 3 figures, 10 tables.

PURIFICATION

315 PROCESS FOR UPGRADING ARSENIC-CONTAINING OILS. Sullivan, R.F. (to Chevron Research Co.). US Patent 4,141,820. 27 Feb 1979. Filed date 18 Aug 1977. 10p.
A method is provided for avoiding feed-transfer-line plugging by a deposit comprising arsenic in hydroprocessing an oil containing an arsenic contaminant. In the method, a mixture of hydrogen gas and the oil is formed in situ in a bed of porous particulate contact material.

316 PROCESS FOR THE PRODUCTION OF DISTILLATE FUELS FROM OIL SHALES AND BY-PRODUCT THEREFROM. Morrell, J.C. US Patent 4,161,441. 17 Jul 1979. Filed date 31 Oct 1977. 20p.
A continuous process for removing a substantial amount of the water present in oil shale prior to retorting the same to facilitate the rate of recovery of the oil therefrom in the retorting step of the process and to substantially increase the capacity of the latter step in the process and improve the overall efficiency thereof is described. The oil shale in subdivided form is subjected to indirect heat treatment with hot combustion gases in a partial dehydration step under relatively milder temeprature conditions than that of the retort. The vapors and gases from the partial dehydration step, in the temperature range from the prevailing temperature up to about 550°F to about 650°F, and for a sufficient time to remove substantial to major amounts of free and combined water from the oil shale accompanied by considerable amounts of oil distillate are collected. Thereafter the heated partially dehydrated oil shale is passed to the retorting step for further indirect heat treatment in the approximate range of about 850°F to about 1000°F. The vapors from the retorting step are then fractionated to remove a light overhead product comprising vapors of low boiling hydrocarbons, water, hydrocarbon gases and ammonia and wherein the heavier conversion oil products from the oil shale are condensed and separated as a liquid for further treatment and use.

317 CATALYST FOR REMOVING SULFUR FROM A GAS. Blanton, W.A. Jr.; Flanders, R.L. (to Chevron Research Company). US Patent 4,152,298. 1 May 1979. Filed date 26 Jan 1978. 28p.
Sulfur oxides are removed from a gas, and the sulfur is converted to hydrogen sulfide by the steps of: (1) reacting sulfur oxides in the gas with alumina to form a solid sulfur-containing compound and remove sulfur oxides from the gas; and (2) contacting the solid compound resulting from step (1) with a hydrocarbon at a temperature of about 800° to 1300°F and reacting the solid sulfur-containing compound with components of the hydrocarbon to form hydrogen sulfide.

318 TWO-STAGE REMOVAL OF SULFUR DIOXIDE FROM PROCESS GAS USING TREATED OIL SHALE. Ridley, R.D.; Cha, C.Y. (to Occidental Oil Shale, Inc.). US Patent 4,140,181. 20 Feb 1979. Filed date 9 Dec 1977. 14p.
PAT-APPL-859,185.
Sulfur dioxide is removed from a process gas

by passing the process gas through a first fragmented permeable mass of particles containing treated oil shale and including alkaline earth metal oxides at a sufficient temperature to remove sulfur dioxide from the process gas. Gas containing sulfur dioxide from the first fragmented mass is passed through a second fragmented permeable mass of particles containing treated oil shale and including alkaline earth metal oxides. Water in the second fragmented mass combines with alkaline earth metal oxides in the second fragmented mass and sulfur dioxide in the gas from the first fragmented mass with resultant removal of sulfur dioxide from gas from the first fragmented mass.

319 DESULFURIZED GAS PRODUCTION FROM VERTICAL KILN PYROLYSIS. Harris, H.A.; Jones, J.B. Jr. (to Paraho Corp.). US Patent 4,092,128. 30 May 1978. Filed date 24 May 1976. 10p.

A gas, formed as a product of a pyrolysis of oil shale, is passed through hot, retorted shale (containing at least partially decomposed calcium or magnesium carbonate) to essentially eliminate sulfur contaminants in the gas. Specifically, a single chambered pyrolysis vessel, having a pyrolysis zone and a retorted shale gas into the bottom of the retorted shale zone and cleaned product gas is withdrawn as hot product gas near the top of such zone.

PROPERTIES AND COMPOSITION

320 (BETC/RI--78/23) STABILITY CHARACTERISTICS OF HYDROCARBON FUELS FROM ALTERNATIVE SOURCES. Brinkman, D.W.; Whisman, M.L.; Bowden, J.N. (Department of Energy, Bartlesville, OK (USA). Bartlesville Energy Technology Center). Mar 1979. 40p. Dep. NTIS, PC A03/MF A01.

Two samples of gasoline and six samples of jet fuel derived from coal, tar sands or oil shale were subjected to accelerated storage stability tests at 43.3 and 93.3°C. Two samples of commercial, petroleum-based gasoline and one sample of a petroleum based jet fuel also were evaluated in this program for comparative purposes. One gasoline, which was derived from coal via the Fischer--Tropsch process, exhibited a high initial gum content which did not vary over a period of 16 weeks at 43.3°C, but increased significantly from 16 to 32 weeks. A sample of naphtha from tar sands showed moderately high gum level after 32 weeks. Petroleum-based gasolines had moderate gum levels at the end of the storage period. Most of the jet fuels appeared to be relatively stable after 16 weeks of storage; however, after 32 weeks, three of the fuels developed a large amount of gum. After 16 hours at 93.3°C, the coal-derived gasoline had the highest gum content. Correlation of the gum concentration after 32 weeks storage with predicted gum levels based on 16 hours test results was reasonably good for the gasoline samples, but very poor for the jet fuel samples. High-temperature thermal stability test results showed considerable scatter. Considering the primitive nature of some of the synfuels, relative stabilities seem reasonable as initial attempts, but much improvement will be required for commercial acceptance.

321 (CONF-771072--, pp 394-402) ANALYSIS OF OIL SHALE AND OIL SHALE PRODUCTS FOR CERTAIN MINOR ELEMENTS. Dickman, P.T. (Univ. of Wyoming, Laramie); Purdy, M.; Doerges, J.E.; Ryan, V.A.; Poulson, R.E. 1977.

From 3. international conference on nuclear methods in environmental and energy research; Columbia, MO, USA (10 Oct 1977).

The University of Wyoming was contracted by the Department of Energy's Laramie Energy Research Center (LERC) to develop rapid, inexpensive, and simple methods of quantitative and qualitative elemental analysis for products used and generated in the simulated in-situ retorting of oil shale. Alpha particle spectrometry was used to determine the radioisotope content of the aqueous retort products. Alpha particles are mono-energetic and the spectrometry method employed had very low background levels (1 count per 2000 seconds). These factors allow for both the quantitative and qualitative analysis of natural radioisotopes at the 1 ppm level. Sample preparation does not require any chemical treatment. Energy dispersive x-ray fluorescence (XRF) was used for the multi-element analysis of the retort products. The XRF, integrated with a mini-computer, allows rapid analysis of several elements in multiple samples. XRF samples require minimal amounts of preparation and analytical results are highly reproducible. This paper presents the methods developed and preliminary analytical results from oil shale by-products. Results from the analysis of oil shale rocks are not yet ready for presentation.

322 (CONF-781150--4) RELATIVE CHEMICAL COMPOSITION OF SELECTED SYNTHETIC CRUDES. Griest, W.H.; Guerin, M.R.; Clark, B.R.; Ho, C.; Rubin, I.B.; Jones, A.R. (Oak Ridge National Lab., TN (USA)). 1978. Contract W-7405-ENG-26. 21p. Dep. NTIS, PC A02/MF A01.

From Symposium on assessing the industrial hygiene monitoring needs for the coal conversion and oil shale industries; Upton, NY, USA (5 Nov 1978).

A knowledge of the composition of synthetic crudes can provide an important input into the assessment of occupational exposure monitoring requirements for the coal conversion and oil shale industries. This paper summarizes comparative compositional studies of coal- and shale-derived crude oils with petroleum crude oils as a reference point.

323 (CONF-790334--2) POLAR CONSTITUENTS OF A SHALE OIL: COMPARATIVE COMPOSITION WITH OTHER FOSSIL-DERIVED LIQUIDS. Rubin, I.B.; Goeckner, N.A.; Clark, B.R. (Western Illinois Univ., Macomb (USA); Oak Ridge National Lab., TN (USA)). 1979. Contract W-7405-ENG-26. 22p. Dep. NTIS, PC A02/MF A01.

From Oil shale symposium; Denver, CO, USA (26 Mar 1979).

Similarities and differences in the polar portions of a variety of types of fossil fuel oils including oil from shale, from several coal liquefaction processes and from a mixture of natural petroleum crudes are described. Samples were fractionated by acid/base distribution as well as by gel partition chromatography which was then followed by acid/base distribution and adsorption chromatography. One subfraction of particular interest was that obtained from the hydrophilic fraction after gel partition chromatography, extracted into a neutral subfraction, and then eluted from an alumina column by methanol. This subfraction was not gas chromatographable, and was partially characterized by elemental analysis, NMR spectroscopy and infrared spectrophotometry.

324 (CONF-790503--4) THREE-DIMENSIONAL CHARACTERIZATION OF THE MECHANICAL PROPERTIES OF GREEN RIVER FORMATION OIL SHALE OF WYOMING'S

TIPTON MEMBER. Chong, K.P. (Univ. of Wyoming, Laramie); Costello, K.L.; Smith, J.W. (Wyoming Univ., Laramie (USA); Department of Energy, Laramie, WY (USA). Laramie Energy Technology Center). 1979. Contract EF-77-S-04-3954. 24p. Dep. NTIS, PC A02/MF A01.

From Spring meeting of society for experimental stress analysis; San Francisco, CA, USA (20 May 1979).

The twelve non-zero coefficients in the stiffness and flexibility matrices for Ticton Member oil shale are expressed in terms of the elastic nonlinear constants consisting of Young's moduli and Poisson's ratios obtained from uniaxial compression tests on square prisms taken from the same horizon of 6-inch core. These matrices relate the three-dimensional stresses and strains, from which data such as pressure versus volume changes can be derived. Pertinent independent variables on the elastic constants include organic volume and stress levels. Physical model and regression analyses are developed for these elastic constants.

325 (CONF-7809103--) SECOND ANNUAL COMBUSTION AND FUELS TECHNOLOGY PROGRAM CONTRACTOR REVIEW MEETING, SEPTEMBER 18--21, 1978, ARLINGTON, VA. (Department of Energy, Washington, DC (USA). Div. of Fossil Fuel Utilization). 1978. 291p. Dep. NTIS, PC A13/MF A01.

From Combustion and fuels and technology program contractor meeting; Arlington, VA, USA (18 Sep 1978).

Papers were presented at the meeting on combustion technology, waste fuel utilization, boilers and furnaces, internal combustion engines, engine optimization, exhaust emissions, effects of microwaves on combustion, swirl combustors, Raman scattering, laser spectroscopy uses in combustion research, alternative fuels, and residues and wastes. (JRD)

326 (COO--4017-3) TRACE ELEMENTS IN OIL SHALE. PROGRESS REPORT, 1976--1979. Chappell, W.R. (Colorado Univ., Boulder (USA)). 1979. Contract EY-76-S-02-4017. 333p. Dep. NTIS, PC A15/MF A01.

The overall objective of the program is to evaluate the environmental and health consequences of the release of toxic trace elements (As, B, F, Mo, Se) by shale oil production and use. Some of the particularly significant results are: The baseline geochemical survey shows that stable trace elements maps can be constructed for numerous elements and that the trends observed are related to geologic and climatic factors. Shale retorted by above-ground processes tends to be very homogeneous (both in space and in time) in trace element content. This implies that the number of analytical determinations required of processed shales is not large. Leachate studies show that significant amounts of B, F, And Mo are released from retorted shales and while B and Mo are rapidly flushed out, F is not. On the other hand, As, Se, and most other trace elements ae not present in significant quantities. Significant amounts of F and B are also found in leachates of raw shales. Very large concentrations of reduced sulfur species are found in leachates of processed shale. Upon oxidation a drastic lowering in pH is observed. Preliminary data indicates that this oxidation is catalyzed by bacteria. Very high levels of B and Mo are taken up in some plants growing on processed shale with and without soil cover. These amounts depend upon the process and various site specific characteristics. In general, the amounts taken up decrease with increasing soil cover. On the other hand, we have not observed significant uptake of As, Se, and F into plants. There is a tendency for some trace elements to associate with specific organic fractions, indicating that organic chelation or complexation may play an important role. In particular, most of the Cd, Se, and Cr in shale oil is associated with the organic fraction containing most of the nitrogen-containing compounds.

327 (FE--2346-24) MECHANICAL CHARACTERISTICS OF ANTRIM SHALE. INTERIM REPORT, APRIL 1977--JANUARY 1978. Kim, K. (Michigan Technological Univ., Houghton (USA). Dept. of Mining Engineering). Feb 1978. Contract EX-76-C-01-2346. 93p. Dep. NTIS, PC A05/MF A01.

A laboratory investigation has been conducted to determine the basic mechanical properties of Antrim oil shale. The strength and deformation properties were studied in quasi-static uniaxial compression, ultrasonic velocity, point load strength and surface hardness tests. Young's modulus and compressive strength were found to decrease with increasing kerogen content while Poisson's ratio remained at a fairly constant level. The density decreased in a linear fashion with increasing kerogen content. The floor rocks showed much greater strength, Young's modulus and Poisson's ratio in comparison with oil shale. A distinct characteristic of Antrim shale was the extreme weakness of the bedding plane which caused a great difficulty in sample preparation. This strength anisotropy would be of great importance in the design of bed preparation methods such as massive hydraulic fracturing and explosives fracturing. 28 figures, 13 tables.

328 (FE--2537-9) CHARACTERIZATION OF COAL-DERIVED LIQUIDS AND OTHER FOSSIL FUEL RELATED MATERIALS EMPLOYING MASS SPECTROMETRY. QUARTERLY REPORT, SEPTEMBER 29--DECEMBER 29, 1978. Scheppele, S.E. (Oklahoma State Univ., Stillwater (USA). Dept. of Chemistry). 29 Jan 1979. Contract EX-76-S-01-2537. 19p. Dep. NTIS, PC A02/MF A01.

The standard electron multiplier of the CEC 21-110B mass spectrometer was replaced with a Hamamatsu electron multiplier. The change allowed the electron multiplier to be operated at a higher gain with about the same noise level on the output signal as with the standard electron multiplier operating at lower gains. The dynamic resolution of the mass spectrometer was determined when the static resolution was set for a value of 13,000. Field-ionization mass spectra, FI/MS, were obtained for the following saturate fractions: Arco Shale Concentrates, 200-325°C, 325-425°C, and 425°C+; South Swan Hills Concentrate 370-535°C; and Utah Crude Oil No. 72054. The molecular ion intensities in the FI/MS of each sample were converted into carbon number distributions as a function of Z(H). The weight percents across each Z(H) series were summed to obtain total weight percents as a function of saturate type. Steps in completing the interfacing of the Nova 3/12 data acquisition system to the comparator-microdensitometer have been taken. An outline of the steps which have been completed and those which will be completed to implement the interfacing is given. Also preliminary designs are given in this report for the interface circuitry and the interface software. High- and low-resolution field-ionization mass spectral data were acquired for 19 monoaromatic, diaromatic, and polyaromatic polar concentrations. These samples were analyzed for the Separations and Characterization Group at

the Bartlesville Energy Technology Center. Also acquisition of high-resolution field-ionization mass spectral data for the remaining asphaltene fractions from the COED coal liquid was completed.

329 (FE--8028-1) PREDICTION OF IN-SITU STRESSES FROM DIRECTIONAL PROPERTIES OF ROCK CORES FOR FIELD DEVELOPMENT OF DEVONIAN SHALE. Peng, S.S.; Okubo, S. (West Virginia Univ., Morgantown (USA). Coll. of Mineral and Energy Resources). Aug 1977. Contract EY-76-S-21-8028. 65p. Dep. NTIS, PC A04/MF A01.

The directional properties of Devonian shale were determined through four physical property measurements: Ultrasonic Velocity Measurement, Point Load Test, Brazilian Test and Measurement of Directional Elastic Constants. The core was taken from Well No. 20403 in Lincoln County, WV. The core with a total of 500 ft. consists of the following three sections: 2720 to 2836 ft., 3402 to 3473, and 3710 to 4026 ft. depth. The results of laboratory core analyses are as follows: (1) bedding planes are quite distinct; (2) the most preferred direction of fractures in the bedding plane is the 60° direction (N 60°E).

330 (GJBX-4(79)(Vol.1)) ENGINEERING ASSESSMENT AND FEASIBILITY STUDY OF CHATTANOOGA SHALE AS A FUTURE SOURCE OF URANIUM. (Mountain States Research and Development, Tucson, AZ (USA); Toups Corp., Orange, CA (USA)). Jun 1978. Contract EY-76-C-13-1664. 350p. Dep. NTIS, PC A15/MF A01.

This report describes the engineering, feasibility, economics, and environmental aspects of exploitation of Chattanooga Shale to recover U, synthetic crude oil, and byproduct Th, NH_3, S, Mo, V, Ni, and Co. It is concluded that the shale is a potential source of U, energy, and byproduct metals. This volume of the report covers the engineering description, feasibility, and economics of exploitation of the shale. (DLC)

331 (GJBX-4(79)(Vol.2)) ENGINEERING ASSESSMENT AND FEASIBILITY STUDY OF CHATTANOOGA SHALE AS A FUTURE SOURCE OF URANIUM. (Mountain States Research and Development, Tucson, AZ (USA); Toups Corp., Orange, CA (USA)). Jun 1978. Contract EY-76-C-13-1664. 366p. Dep. NTIS, PC A16/MF A01.

This volume characterizes the major baseline environmental features of the Chattanooga Shale study and projects the effects which may accrue from implementation of a large scale development to recover uranium from the shale. Environmental, socioeconomic, and regulatory impacts are covered. The prototype project is located in Dekalb County in Tennessee. (DLC)

332 (GJBX-4(79)(Vol.3)) ENGINEERING ASSESSMENT AND FEASIBILITY STUDY OF CHATTANOOGA SHALE AS A FUTURE SOURCE OF URANIUM. (Mountain States Research and Development, Tucson, AZ (USA); Toups Corp., Orange, CA (USA)). Jun 1978. Contract EY-76-C-13-1664. 212p. Dep. NTIS, PC A10/MF A01.

This volume contains five appendixes: Chattanooga Shale preliminary mining study, soils data, meteorologic data, water resources data, and biological resource data. The area around DeKalb County in Tennessee is the most likely site for commercial development for recovery of uranium. (DLC)

333 (LA-UR-79-832) DETERMINING THE DYNAMIC PROPERTIES OF DEVONIAN GAS SHALE. Olinger, B. (Los Alamos Scientific Lab., NM (USA)). 1979. Contract W-7405-ENG-36. 11p. (CONF-790606-2). Dep. NTIS, PC A02/MF A01.

From 20. US symposium on rock mechanics; Austin, TX, USA (3 Jun 1979).

Four techniques are used to characterize the response of Eastern Devonian gas shales to impulsive loading. First, the elastic moduli of the transverse, isotropic shales are measured. Then, tensile strengths are deduced from an examination of samples recovered from impacts with characterized plates. Third, shock velocities, release wave velocities and stress-strain paths is determined from measured stress wave histories at various depths in the shales. Finally, the pressure-volume relation for these shales are determined from shock velocity measurement to pressures as high as 80 GPa (800 kbars) using impacts from high-explosive driven metal plates.

334 (LA-UR--79-1147) ELUCIDATION OF GEOMATRICES BY LASER PYROLYSIS/GAS CHROMATOGRAPHY AND PYROLYSIS/MASS SPECTROMETRY. Jones, C.E.R.; Vanderborgh, N.E. (Los Alamos Scientific Lab., NM (USA)). 1979. Contract W-7405-ENG-36. 22p. (CONF-790931--1). Dep. NTIS, PC A02/MF A01.

From 14. international symposium on advances in chromatography; Lausanne, Switzerland (24 Sep 1979).

Present methods for the examination of organics entrained in geological matrices ae tedious even if not fallible. Thermal degradative techniques combined with the separatory power of a gas chromatographic column or a quadrupole mass spectrometer operating low-voltage electron impact mode afford rapid access to detailed profiles of such materials. The virtue of these parallel approaches are compared and contrasted in application to the elucidation of Devonian Shale and other geological material.

335 (LBL--8888) USE OF ZEEMAN ATOMIC ABSORPTION SPECTROSCOPY FOR THE MEASUREMENT OF MERCURY IN OIL SHALE GASES. Girvin, D.C.; Hadeishi, T.; Fox, J.P. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). Mar 1979. Contract W-7405-ENG-48. 19p. (CONF-790334--4). Dep. NTIS, PC A02/MF A01.

From Oil shale symposium; Denver, CO, USA (26 Mar 1979).

A technique to continuously measure total mercury in a gas stream in the presence of high concentrations of organics, smoke, oil mist, and other interfering substances is described. The technique employees Zeeman atomic absorption (ZAA) spectroscopy as the mercury detector, which has been successfully used to measure mercury in oil shale offgases. The instrument consists of a light source which provides the 2537 A mercury emission line; a furnace-absorption tube assembly where the sample is vaporized and swept into the light path and a detector which converts the signal into an ac voltage for processing. Sample gas is heated to 900°C in the furnace-absorption tube assembly aligned with the optical axis of the ZAA spectrometer. The 2537 A mercury emission line (π) and a reference line (sigma) are generated by a single discharge lamp operated in a 15 kG magnetic field. The difference between the π and sigma components is taken by a lock-in-amplifier and converted to a signal which is proportional to the amount of mercury in the gas.

336 (LBL--8901) INTERCOMPARISON STUDY OF ELEMENTAL ABUNDANCES IN RAW AND SPENT OIL SHALES. Fox, J.P.; Evans, J.C.; Wildeman,

T.R.; Fruchter, J.S. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). Mar 1979. Contract W-7405-ENG-48. 25p. (CONF-790334--11). Dep. NTIS, PC A02/MF A01.

From Oil shale symposium; Denver, CO, USA (26 Mar 1979).

Two samples each of raw oil shale and spent oil shale were prepared as reference samples and analyzed by four laboratories using neutron activation analysis, x-ray fluorescence spectrometry, atomic absorption spectroscopy, and other techniques. Excellent agreement was obtained between techniques and laboratories except for the thin-film XRF technique. The %RMS deviations were less than or equal to 10% for 85% of the values. In general, the INAA analysis procedures yielded the most accurate and precise results. The XRF and colorimetric methods compared well with INAA but they were not as precise. Poor interlaboratory agreement was obtained for Cr, Co, Dy, and Sm by INAA, and an analytical problem was noted for As and Zr. Additional work is required to develop and validate reliable methods for B, F, Cd, and As.

337 (LBL--9030) PARTITIONING OF MAJOR, MINOR, AND TRACE ELEMENTS DURING SIMULATED IN SITU OIL SHALE RETORTING IN A CONTROLLED-STATE RETORT. Fox, J.P.; Mason, K.K.; Duvall, J.J. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.; Department of Energy, Laramie, WY (USA). Laramie Energy Technology Center). Apr 1979. Contract W-7405-ENG-48. 7p. (CONF-790440--4). Dep. NTIS, PC A02/MF A01.

From 12. oil shale symposium; Golden, CO, USA (18 Apr 1979).

The partitioning of 49 elements during 15 runs of the Laramie Energy Technology Center's controlled-state retort was investigated. Mass balances and mobility factors were determined for each element for each run. The average mass balance closure for 47 elements (Cd and Hg excluded) for the 15 runs was 101 +- 7%. Mobility was used to identify five groups of elements. Over 25% of the raw shale elemental mass of Group 1 elements (H, N, S, Cd, Hg, inorganic C, and organic C) is distributed primarily to the gas and oil. From 1% to less than 10% of the raw shale elemental mass of the Group 2 elements (Se, Ni, As, and Co) is partitioned primarily to the oil phase. The Group 3 to 5 elements, all of which have mobilities that are less than 1%, include Cr, Sb, Zn, Cu, Na, Mo, V, Ga, Fe, Mn, U, Ba, Dy, La, K, Mg, Sm, Cs, Eu, Hf, Rb, Ce, Sr, Al, Ca, Sc, Ti, Yb, and Th. The study indicates that elemental partitioning in the controlled-state retort is affected by mineralogical residence and retort operating conditions. Significant differences in the mobility and mass distribution patterns were observed for Green River, Antrim, and Moroccan oil shales. It is proposed that for a given mineralogy, elemental partitioning is controlled primarily by high-temperature chemical reactions within the reaction zone and secondarily by interactions between the products (oil, gas, and water) and the cool shale ahead of the reaction zone. Retorting temperature and atmosphere also affect partitioning trends. Temperature controls the degree of kerogen conversion and mineral decomposition; input gas composition determines the atmosphere, that is, reducing or oxidizing (although this latter factor did not significantly affect partitioning here).

338 (MERC/SP--77/5, pp 49-67) ABUNDANCE AND DISTRIBUTION OF SOME CHEMICAL ELEMENTS IN THE CHATTANOOGA, OHIO, AND NEW ALBANY SHALES IN KENTUCKY. Blackburn, W.H.; Dennen, W.H.; Davis, P.A. (Univ. of Kentucky, Lexington). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

Chemical determinations of 25 major, minor, and trace elements have been made on 60 outcrop samples of the Devonian shale collected around the Cincinnati Arch. No attempt was made to provide stratigraphic control and, since all the material was weathered to some extent, the data probably represent the maximum geochemical range to be anticipated in core samples. Elements showing bimodal or wide variability may be expected to be most useful in stratigraphic or areal analyses. These include V, Co, Ni, Zn, Mo, Ca, S, Y, Sr, and U. Other elements examined are unimodal with little variability and are probably least useful in this context. A relationship between concentrations of variable elements and modal components is also noted. 13 figures.

339 (MERC/SP--77/5, pp 230-258) CHARACTERIZATION AND ANALYSIS OF DEVONIAN SHALES. I. PHYSICAL CHARACTERIZATION. Kalyoncu, R.S.; Coppins, W.G.; Hooie, D.T.; Snyder, M.J. (Battelle Columbus Labs., OH). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

Physical characterization of Eastern Devonian shales is an important step in Battelle's Columbus Laboratories' efforts to determine the relationships between shale characteristics, hydrocarbon content, and well location. Among the physical properties to be determined are density, surface area, pore size, pore size distribution, and permeability. Methods of physical characterization, and some characterization data, are reported and several problems are discussed. The initial findings and some possible implications about relationships with other data on the same samples are also discussed. 10 figures, 8 tables.

340 (MERC/SP--77/5, pp 259-296) NEW DATA FOR URANIUM, THORIUM, CARBON, AND SULFUR IN DEVONIAN BLACK SHALE, FROM WEST VIRGINIA, KENTUCKY, AND NEW YORK. Leventhal, J.S.; Goldhaber, M.B. (Geological Survey, Denver, CO). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

Data are presented for uranium, thorium, organic carbon, and sulfur in Devonian Black Shale. Uranium varies between 1.5 to 38 ppM. This range in part reflects regional trends, but within a given core, values from 1.5 to 15.8 ppM, (Cattaraugus County, New York); 3.2 to 38 ppM, (Perry County, Kentucky); 3.4 to 36.6 ppM, (Lincoln County, West Virginia); 3.4 to 21 ppM, (Jackson County, West Virginia) were noted. Some large concentration changes over short (approx. 1 ft) depth intervals were documented. Thorium is much less variable than uranium with a mean value of 15 ppM, near the mean value of 12 ppM previously reported for more typical marine shale. Both uranium and carbon are generally higher than the average values quoted for shales of 3.7 ppM for uranium and 2.1% for carbon. Uranium is positively correlated with organic carbon and total sulfur. The plots of the carbon, sulfur, and uranium with depth for Perry County, Kentucky, and Jackson County, West Virginia, in particular show a very good correspondence between uranium and carbon. In the Perry County core the uranium and sulfur relationship is not as closely correlated in the upper part of the shale, but becomes so, in the lower portion. 13 figures, 16 tables.

341 (MERC/SP--77/5, pp 659-666) PROCEDURES FOR THE CHARACTERIZATION OF DEVONIAN SHALES. Brownell, W.E. (Alfred Univ., NY). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

Elemental, mineralogical, and physical characterization of Devonian eastern gas shales is being done at Alfred University. In order to obtain the best data possible, several new procedures have been developed, especially in the area of mineralogical analysis. Forty-one elements are being determined quantitatively using conventional chemical procedures, specific ion electrode technique, atomic absorption, and Leco gas analyzers. A computerized x-ray diffraction procedure has been developed for qualitative analysis and quantitative determinations of the major minerals present in the shales. X-ray diffraction is also being used for measuring the preferred orientation of the disilicate minerals with respect to the core axis. Trace minerals are being identified and the sizes of the quartz grains are being measured by optical microscopy. A special disaggregation and mounting technique has been developed for the determination of the quartz particle-size distributions. Physical characterization is being done by measuring density, pore-size distribution, sonic velocity, directional tensile strength, point load strength with fracture patterns noted, and air permeability. A special apparatus and technique has been developed for the permeability measurements. 5 figures, 1 table.

342 (MERC/SP--77/5, pp 524-545) CHARACTERIZATION AND ANALYSIS OF DEVONIAN SHALES: GAS COMPOSITION AND RELEASE RATES. Snyder, M.J.; Rausch, M.P.; Ogden, J.S.; Coutant, R.W. (Battelle Columbus Labs., OH). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

A program is being conducted to determine the relationships between shale characteristics, hydrocarbon gas content, and well location. Ultimately, about 1000 core samples of gas bearing Devonian shales will be selected and sealed in special containers to preserve their approximate "down-hole" condition, and the gas-release characteristics and various chemical, physical, and lithologic characteristics will be determined. Hydrocarbon distributions and release rates of these hydrocarbons from selected Devonian shale samples are being determined as a major effort on the program. Procedures employed involve the use of gas chromatography for composition analysis; recording microbalance and continuous-flow FID total-hydrocarbon systems for kinetics measurements; and modified Fischer Assay procedure for determination of residual heavy hydrocarbons. Preliminary measurements of these types have now been completed for approximately 20% of the projected total of 1000 samples from various well sites in the Appalachian and Illinois basins. Results of these measurements and preliminary conclusions are discussed. 10 figures, 10 tables.

343 (MERC/SP--77/5, pp 572-588) STRUCTURAL CHARACTERIZATION OF BITUMEN AND KEROGEN FROM DEVONIAN SHALE. Yen, T.F.; Wen, C.S.; Tang, J.I.S.; Kwan, J.T.; Young, D.K.; Chow, E. (Univ. of Southern California, Los Angeles). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

Both the bitumen and kerogen concentrates from a Cottageville Devonian Marine shale core sample have been isolated. The bitumens are further fractionated into hydrocarbons, polar resins, and asphaltic material. Each fraction has been individually characterized. Carbon perference index (CPI) was used as a parameter for the correlation of the maturation of shales. The structure of kerogen has been elucidated by physical as well as chemical methods. The molecular structure was compared with that of the lacustrine shale of the Green River Formation. 10 figures, 5 tables.

344 (MERC/SP--77/5, pp 589-595) INTERNAL SURFACE AREA AND POROSITY IN EASTERN GAS SHALES FROM THE SORPTION OF NITROGEN, CARBON DIOXIDE, AND METHANE: A STATUS REPORT. Thomas, J. Jr.; Frost, R.R. (Illinois State Geological Survey, Urbana). Mar 1978.

From Eastern gas shale program conference; Morgantown, WV, USA (17 Oct 1977).

The adsorption of N_2 at -196°C and of CO_2 at -77°C on eastern gas shales reveals significant differences in their micropore structures. Owing to differences in the activated diffusion of the two gases at their respective adsorption temperatures, as studies on molecular sieves and coals have shown, CO_2 is able to penetrate pores less than 4 to 5 Å in diameter, whereas N_2 is unable to do so. One measure of this difference is in the internal surface area (ISA) estimated from the BET method. For example, shale samples from a Kentucky core, with CO_2 as the adsorbate, have ISA values ranging from 10 to 39 m^2/g, whereas the ISA values from N_2 adsorption on the same samples range from 0.8 to 8.7 m^2/g. The diffusion rate of a gas initially contained within such an ultramicroporous network will be greatly decreased in comparison with the diffusion rate from shales containing larger pores. High-pressure (up to 80 atmospheres) methane sorption isotherms near room temperature are shown for selected shale samples. These isotherms provide supplemental information with regard to total porosity and the gas-holding capacity of shales at depth of burial. figure, 4 tables.

345 (METC/CR--78/16) METHOD OF ANALYSIS AND PRECISION OF X-RAY DIFFRACTION DATA FROM OHIO SHALE. Carlton, R.W. (Ohio Dept. of Natural Resources, Columbus (USA). Div. of Geological Survey). Oct 1978. Contract EY-76-S-05-5200. 28p. Dep. NTIS, PC A03/MF A01.

Sample preparation and methods of calculation used by the Division of Ohio Geological Survey in its mineralogic and physical characterization of the Upper Devonian black shales are described. Methods of sample mounting, used in conjunction with a Philips automatic sample changer (ASC), allow analysis of a large number of samples by x-ray diffractometry. Because of the time saved wth an ASC, each sample can be scanned twice to increase the precision of the results. The reproducibility of the x-ray data, expressed as relative deviation, ranges from about +-2 to +-10% in samples for which the percent total integrated intensity (%TII) is above 6%.

346 (METC/SP--78/6(Vol.1), pp 396-403) CARBON ISOTOPES IN THE DEVONIAN SHALE SEQUENCE: UTILITY AS PROVENANCE INDICATORS. Maynard, J.B. (Univ. of Cincinnati). Oct 1978.

From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).

The type of organic matter present in the shale--marine or terrestrial--may be important in gas generation because terrestrial carbon appears to yield more methane than marine-derived carbon. The ratio of C^{13} to C^{12} in the

organic matter of recent sediments (expressed as delta C^{13}) is a function of the provenance of the carbon: non-marine C is relatively negative, around -26, while marine C is about -21. The Devonian Shale sequence also shows a proximal-distal variation in C isotopes. Wood samples and non-marine black shales have delta C^{13} values of -25 to -26, similar to the modern value. Marine shales, however, are more negative, ranging from -27 to -31, the values becoming more negative to the west and northwest within a given stratigraphic interval. Carbon isotopes also reflect distal-proximal changes in the organic matter at a given locality. Usually, gray shales have less negative (i.e. less marine) values than black shales. For instance, the Bedford gray shale in Richland County, Ohio averages -27.6 whereas the immediately underlying Cleveland black shale averages -29.2. There is no explanation for the difference between the Devonian and the recent pattern, except to suggest that perhaps the marine organisms were different. Carbon isotope results suggest that Eastern Kentucky and Western West Virginia should be the most favorable areas for gas, and that Central Ohio and the Illinois Basin should be poor.

347 (METC/SP--78/6(Vol.1), pp 431-442) DIFFUSION EXPERIMENTS ON CORED SAMPLES OF DEVONIAN SHALE. Smith, R.D. Oct 1978.
From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).
A study was conducted to measure the diffusion coefficients of methane in certain shale samples from gas wells in Ohio and West Virginia. Seven experimental tests were carried out on six different samples taken from 4-inch core. The method used was gas flow through a slab of shale by applying high pressure on one side. The pressure increase was measured on the low pressure side with a mercury manometer. Pure methane gas was used as the permeating fluid. The mathematical treatment was based on Paul and DiBenedetto. The solution involved the summation of an infinite series which was solved by computer. It was determined that 200 terms of the series were sufficient to give the desired accuracy. An average diffusion coefficient was found to be about 6.8×10^{-8} cm^2/s (6.9×10^{-10} darcys). The range went from unmeasurable to 4.7×10^{-7} cm^2/s (1.3×10^{-9} darcys). The unmeasurable test ran for 24 days and the concentration of gas did not increase in the low pressure chamber. This mathematical method is excellent for determining very small diffusivities because of its time dependence. That is the longer a test is continued, the smaller the diffusivities that can be measured.

348 (METC/SP--78/6(Vol.1), pp 273-279) ANALYSIS OF BLACK SHALE BY INDUCTIVELY COUPLED PLASMA. Lechler, P.; Leininger, R.K. (Indiana Geological Survey, Bloomington). Oct 1978.
From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).
A major portion of the inorganic analysis of New Albany Shale by the Indiana Geological Survey will be performed on a direct-reading inductively coupled (argon) plasma-optical emission spectrometer. The major rock-forming elements (except oxygen, carbon, sulfur, and hydrogen) will be determined by ICP after dissolution of the 850°C ash in a Teflon (TM) bomb of unique design. Several trace elements will also be determined by ICP after wet ashing and dissolution by hydrofluoric acid. Initial results from the spectrometer have shown that it is accurate for the determination of both major metallic and several trace elements in silicate rocks. The results for two reference samples by ICP versus other analytical methods are compared. Major and some trace element data for the Phegley No. 1 core, Sullivan County, Indiana, are also presented.

349 (METC/SP--78/6(Vol.1), pp 129-137) CHEMICAL AND PHYSICAL PROPERTIES OF MICHIGAN ANTRIM SHALE. Young, D.C. (Dow Chemical Co., Midland, MI). Oct 1978.
From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).
The Dow Chemical Company has completed two years of a four-year, $14 million contract with DOE in a project to assess the feasibility of recovering energy from Antrim oil shale by an in situ process. A significant part of this project, shale characterization, is being carried out in five universities in Michigan under subcontracts with Dow. While the objective of this contract is different from that of the Eastern Gas Shales Project, the shale characterization work is similar. Contact between participants in the two projects should be mutually beneficial. The purpose of this paper is to outline the studies of chemical and physical properties of Antrim shale which are underway and to identify the individuals and institutions involved. Representative results which have been obtained to date are included.

350 (METC/SP--78/6(Vol.2), pp 151-163) LASER PYROLYSIS--GAS CHROMATOGRAPHY: A MODERN SOURCE ROCK ASSAY TECHNIQUE. Vanderborgh, N.E; Fletcher, M.A. (Los Alamos Scientific Laboratory, NM). Oct 1978.
From 2. Eastern gas shales symposium; Morgantown, WV, USA (16 Oct 1978).
Laser pyrolysis--gas chromatography is being developed as a new method for rapid organic geochemical characterization of gas shales. This technique generates gaseous products which are separated and analyzed on a chromatographic system. Data show that the acetylene yield can be correlated to total carbon content. Moreover this technique can be completed in a few seconds. Characterization of higher molecular weight pyrolysis fragments suggests that organic shale constitutents thermally generate unsaturated linear hydrocarbons, much like low rank coals. 7 figures, 2 tables.

351 (METC/SP--79/6, pp 425-432) CROSS-POLARIZATION CARBON-13 NMR OF KEROGENS FROM DEVONIAN SHALE AND COAL. Beer, S.K.; Headley, L.C. (Morgantown Energy Technology Center, WV). 1979.
From 3. Eastern gas shales symposium; Morgantown, WV, USA (1 Oct 1979).
The carbon-13 cross polarization (CP) technique has been applied to Hazard, KY, and Cottageville, WV, Devonian gas shale kerogens and Arkwright, WV, bituminous and Roseburd, MT, subbituminous coal kerogens. CP spectral features and estimated aromatic fractions were compared with C/O and H/C atomic ratios determined from elemental analyses. CP lineshapes were generally similar in most samples although there may be some variance in the downfield part of the aliphatic region. Definition of the aromatic and aliphatic lines was generally good with the exception of the Hazard sample. Possibly because of residual mineral matter or changes in the organic content during the kerogen extraction process, we did not find either carbon contents or C/O ratios to be good predictors of spectral features in kerogens despite the effects of C-O and C=O bonds are expected to have on the aliphatic line. In particular, both the carbon content and C/O ratio in the coal kerogens are low compared to those in a wide variety of

bituminous coals, although this is not obvious from the CP spectra. The coal kerogens, like bituminous coals, were found to be highly aromatic substances, while the shale kerogens were more aliphatic. The aromatic fraction is seen to decrease in a roughly linear fashion as the H/C atomic ratio increases. 5 figures, 1 table.

352 (METC/SP--79/6, pp 499-509) ELUCIDATION OF GEOMATRICES BY LASER PYROLYSIS/GAS CHROMATOGRAPHY AND PYROLYSIS/MASS SPECTROMETRY. Vanderborgh, N.E.; Jones, C.E.R. (Los Alamos Scientific Lab., NM). 1979.
From 3. Eastern gas shales symposium; Morgantown, WV, USA (1 Oct 1979).
Present methods for the examination of organics entrained in geological matrices are tedious even if not fallible. Thermal degradative techniques combined with the separatory power of a gas chromatographic column or a quadrupole mass spectrometer operating low voltage electron impact mode afford rapid access to detailed profiles of such materials. The virtue of these parallel approaches are compared and contrasted in application to the elucidation of Devonian Shale and other geological material.

353 (MLM--2640) MATERIAL BALANCE ASSAY OF DEVONIAN GAS SHALE. Kapsch, D.M.; Frye, J.O.; Nunn, E.B. (Mound Facility, Miamisburg, OH (USA)). 20 Aug 1979. Contract EY-76-C-04-0053. 20p. Dep. NTIS, PC A02/MF A01.
A Devonian shale retorting method, similar to the TOSCO Material Balance Assay, was developed. Oil, gas, water, and spent shale collected from the thermal decomposition of Devonian shale provide material balance closure. Elemental and other analyses were used to characterize the products and evaluate their fuel potential. The precision of each analysis was estimated by running a series of material balance assays on a composite shale sample. The elemental composition of this shale oil was shown to remain unchanged on aging. Typical material balance assays from each well where core samples were taken are presented.

354 (ORNL--5421) FOSSIL ENERGY PROGRAM. QUARTERLY PROGRESS REPORT FOR THE PERIOD ENDING MARCH 31, 1978. McNeese, L.E. (Oak Ridge National Lab., TN (USA)). Jul 1978. Contract W-7405-ENG-26. 237p. Dep. NTIS, PC A11/MF A01.
The large commercial coal conversion plants are predicted to involve thick section construction of ferritic steels up to the 250- to 350-mm range (10 to 14 in.). The microstructures and properties resulting from cooling rates at the centers of thick sections are being experimentally simulated to determine whether the properties will be adequate. Data for 2¼ Cr-1 Mo steel, a leading candidate alloy, are presented. Suitable welding guidelines for depositing type 320 Cb stainless steel on 2¼ Cr-1 Mo steel and on plain carbon steel by these methods are being explored. Results of environmental and health studies related to various fossil energy processes are described. In particular, progress is reported on the development and validation of several analytical and testing techniques employed to identify biologically active constituents, on the co-mutagenic properties of several polyaromatic hydrocarbons, on the transport, transformation, and toxicity of various organic and inorganic materials in either aquatic or terrestrial systems, and on the removal of coal conversion products from aqueous effluents by sorption, ozonation, biological treatment. A program aimed at developing a process for separating pyritic sulfur and other inorganic constituents from dry pulverized coal was begun in 1977. Initial work has concentrated on defining the magnetic separability of several Eastern coals and on demonstrating technical feasibility of a batch high-gradient magnetic separator/fluidized bed system. The separability studies demonstrated close agreement between magnetic separability and the conventional float sink separability for the coals tested. Investigations of methods for processing fly ash have led to the development of two new processes, Calsinter and $NaCl/Na_2Co_3$ sinter leach, capable of recovering >90% of the aluminum present in fly ash.

355 (ORO--5202-T3) BLACK SHALE STUDIES IN KENTUCKY. QUARTERLY REPORT, APRIL-JUNE 1979. (Kentucky Geological Survey, Lexington (USA). Dept. of Geology). 1979. Contract EY-76-C-05-5202. 240p. Dep. NTIS, PC A11/MF A01.
The bulk of this document comprises a thesis by Gerald Markowitz, which is a geochemical study of the Upper Devonian-Lower Mississippian black shales in eastern Kentucky. (DLC)

356 (ORO--5205-7) CHARACTERIZATION AND ANALYSIS OF DEVONIAN SHALES AS RELATED TO RELEASE OF GASEOUS HYDROCARBONS. QUARTERLY TECHNICAL PROGRESS REPORT, APRIL--JUNE 1978. Kalyoncu, R.S.; Snyder, M.J. (Battelle Columbus Labs., OH (USA)). 8 Aug 1978. Contract EY-76-C-05-5205. 393p. Dep. NTIS, PC A17/MF A01.
Objective is to determine the relationships between the shale characteristics, hydrocarbon gas contents, and well location, for assessing the productive capacity of the Eastern Devonian Gas Shale deposits and guiding research, development, and demonstration projects to enhance the recovery of natural gas from the shale deposits. One well was sampled during this reporting period. Another well from Monongalia County, WV (M-1) was cored in April. 31 samples were obtained for Battelle with additional 55 samples canned for other DOE contractors. Characterization tasks on shale samples from R-146 (Mason County, WV.) and M-1 wells (Monongalia) have been completed. In the preliminary analysis correlations were observed between the hydrocarbon gas contents and can pressure, propane content, well location, oxygen content CO_2 content, bulk density and carbon contents. Higher pressures are attributed to higher hydrocarbon gas contents. For high gas pressures, propane content is an important indication of hydrocarbon gas content. At low gas pressure, butane contents more accurately predict the hydrocarbon gas contents. High CO_2 and carbon contents indicate high hydrocarbon gas values, whereas oxygen contents are inversely related to hydrocarbon gas contents. Analysis of the limited wire-line log data shows that correlations between the laboratory and well log data can be utilized to predict potential hydrocarbon gas contents of the wells. 15 tables, 27 figures.

357 (ORO--5205-9) CHARACTERIZATION AND ANALYSIS OF DEVONIAN SHALES AS RELATED TO RELEASE OF GASEOUS HYDROCARBONS. QUARTERLY TECHNICAL PROGRESS REPORT, OCTOBER--DECEMBER 1978. Kalyoncu, R.S.; Snyder, M.J. (Battelle Columbus Labs., OH (USA)). 15 Jan 1979. Contract EY-76-C-5205. 287p. Dep. NTIS, PC A13/MF A01.
The characterization data obtained during the period October through December 1978 are described. One well in Allegany County, New

York, was sampled in September 1978. A total of 412 samples were collected from the Allegany County, New York well (165 for Battelle and 247 for other DOE/MERC contractors). Two other wells, namely in Wetzel County, West Virginia and Johnson County, Kentucky, were cored during the last quarter of 1978. A total of 109 samples were obtained from the Wetzel County, West Virginia well (46 samples for Battelle and 63 samples for other DOE/MERC contractors). The samples were obtained from depths of 6100 to 6635 feet. Characterization data on I-2 (EGSP Ind. No. 2), Clark County, Indiana, and Y-1 (EGSP New York No. 1), Allegany County, New York wells are reported and discussed. Analysis of the hydrocarbon gases in Y-1 samples indicates that the longer chain hydrocarbon gases (ethane, propane, butane) in these shales are significantly higher than in the previous wells studied. The Indiana well (I-2) shows surprisingly high carbon contents compared with the hydrocarbon gas contents. The carbon contents of the Y-1 (Allegany County, New York) well, on the other hand, are somewhat lower than would be predicted from the hydrocarbon gas contents. Among the physical properties, the I-2 well generally exhibits lower density values than previously studied shales.

358 (ORO--5205-T3) CHARACTERIZATION AND ANALYSIS OF DEVONIAN SHALES AS RELEASE OF GASEOUS HYDROCARBONS. WELL R-109, WASHINGTON COUNTY, OHIO. Kalyoncu, R.S.; Boyer, J.P.; Snyder, M.J. (Battelle Columbus Labs., OH (USA)). 20 Jun 1979. Contract EY-76-C-05-5205. 133p. Dep. NTIS, PC A07/MF A01.

Coring of Well R-109 (Washington County, Ohio) was accomplished in August 1976. A total of 25 samples were collected. Hydrocarbon gas analyses indicate that higher chain hydrocarbon gases (C_2-C_5) make up a significant portion of total hydrocarbons in the shales, but methane is still the dominant single gas. Distinct relationships exist between the carbon and hydrocarbon gas contents, showing increase in hydrocarbon gas contents with increasing carbon. Similar relationships between hydrogen and hydrocarbon gas contents exist, though they are not as pronounced. Gas contents appear not to be related to the bulk densities in any quantitative manner, though organic contents (carbon and hydrogen) seem to be related to bulk density values much more clearly. R-109 shales are virtually impermeable to gases and other fluids, as attempted helium gas permeability measurements indicated extremely small ($< 10^{-12}$ Darcy) permeability values.

359 (TID--28463) FUNDAMENTAL CHARACTERIZATION OF ALTERNATE FUEL EFFECTS IN CONTINUOUS COMBUSTION SYSTEMS. TECHNICAL PROGRESS REPORT NO. 1, AUGUST 15, 1977--AUGUST 14, 1978. Blazowski, W.S. (Exxon Research and Engineering Co., Linden, NJ (USA). Government Research Lab.). 11 Jan 1978. Contract EC-77-C-03-1543. 144p. Dep. NTIS, PC A07/MF A01.

The properties of alternate fuels derived from coal, oil shale, and tar sands can result in significantly different combustion performance compared with conventional specification fuels. For example, decreased hydrogen content can result in increased flame luminosity and exhaust smoke emissions, higher fuel bound nitrogen can result in increased NO/sub x/ emissions, and fuel impurities can result in deposition within the combustion device. Although additional refining and fuel treatment can mitigate these problems to some extent, the approach of adapting the combustion system to utilize fuels having ''unconventional'' properties while operating in an environmentally acceptable manner seems to be most cost effective and energy efficient. This program will provide fundamental information necessary for the efficient pursuit of this approach. The work will be limited to investigation of alternate liquid and gaseous fuels used in continuous combustion systems, with gas turbine systems receiving special attention. The program philosophy is to relate fundamental combustion phenomena to fuel characteristics using analytical models developed with and eventually verified by data obtained in carefully designed experiments. Key combustion properties and ranges of fuel variation of interest to subsequent efforts have been surveyed. Recently initiated experimental work includes the utilization of unique ER and E experimental euipment for evaluation of fuel combustion characteristics. The analytical modeling effort includes new modeling techniques as well as predictions of and comparisons with the experimental results generated. This report is intended to provide background information on the current understanding of alternate fuel efforts in gas turbines. The key technical areas requiring additional study and analysis are identified and prioritized. Current plans for experimental study of the highest priority problem, soot formation, will be briefly reviewed.

360 (UCRL--52619) SURFACE-AREA AND PORE-VOLUME STUDY OF RETORTED OIL SHALE. Slettevold, C.A.; Biermann, A.H.; Burnham, A.K. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 11 Dec 1978. Contract W-7405-ENG-48. 22p. Dep. NTIS, PC A02/MF A01.

The surface area and pore distributions of retorted Colorado oil shale were studied using nitrogen and carbon dioxide adsorption and mercury porosimetry. Shale surface area was studied as a function of the heating rate during retorting. Results were analyzed with the Langmuir; Brunauer, Emmett, and Teller; and Dubinin-Polanyi equations. It was found that surface area correlated well with the amount of residual organic carbon. Also, the surface areas determined with carbon dioxide were substantially larger than those determined with nitrogen. Duplicate samples were decharred by heating in air at 400°C for 24 h. The surface areas of these samples were less than half of those with the residual carbon. The surface areas of the retorted and decharred samples were combined to obtain an estimate of the specific surface area of the residual organic carbon (typically 300 m^2/g). Acid leaching of three samples from those above removed the carbonate minerals. The surface areas determined by carbon dioxide adsorption showed an increase by a factor of two to three over the unleached samples. This effect was attributed to the formation of a sponge like structure caused by the dissolution of micrometer-sized crystals of calcite and dolomite in the shale. The pore characteristics of the retorted shale was also examined by mercury porosimetry and nitrogen adsorption. Scanning electron microscope pictures demonstrate the origin of the porosity.

361 (UCRL--81285) COMBUSTION CALORIMETRY OF OIL SHALES. Crawford, P.C.; Ornellas, D.L.; Lum, R.C.; Johnson, P.G. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 19 Oct 1978. Contract W-7405-ENG-48. 10p. (CONF-781078--2). Dep. NTIS, PC A02/MF A01.

From North American thermal analysis conference; Atlanta, GA, USA (15 Oct 1978).

Samples of raw oil shale and spent shale from combustion-retorting experiments are

burned in a calorimeter to determine their heats of combustion. The shales are mixed with an equal amount of benzoic acid to achieve complete combustion. A platinum crucible with a basket is used to allow minimal contact of sample with platinum. This design reduces quenching effects by permitting oxygen to completely surround the sample. The heats of combustion, ΔH/sub c/, for raw shale range from 1150 to 1250 cal/g while those for spent shale range from -65 to -15 cal/g. The precision of the analysis gives a standard deviation of approximately 5 cal/g. Uncertainties in the sulfur correction and the gas correction, Δn, have the largest effect on the accuracy of the analysis.

362 (UCRL-82078) SAMPLE SIZE REQUIRED FOR ANALYSIS OF OIL SHALE OF WIDELY VARYING GRADE AND PARTICLE SIZE. Carley, J.F. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 1 Mar 1979. Contract W-7405-ENG-48. 19p. (CONF-790334--9). Dep. NTIS, PC A02/MF A01.

From Oil shale symposium; Denver, CO, USA (26 Mar 1979).

Almost all the interesting properties of oil shale vary with its kerogen content, which usually shows a wide range of variation in any lot of mine-run shale, sometimes even in a single large block. Even when approved procedures of sampling and subdivision are followed, misleading analytical results may be obtained if the sample size is inadequate for the range of properties in the lot and the particle sizes involved. A statistical rationale is developed in this paper that leads to an equation and graphical procedure for finding the minimum representative size of a sample of oil shale. This is applied to several types of analyses commonly done on oil shale. We then look into the case of a retorting experiment in which the oil yield exceeded the Fischer assay.

363 CROSS POLARIZATION MAGIC-ANGLE SPINNING ^{13}C NMR SPECTRA OF OIL SHALES. Miknis, F.P. (Dept. of Energy, Laramie, WY); Maciel, G.E.; Bartuska, V.J. Org. Geochem.; 1: No. 3, 169-176(Jul 1979).

Cross polarization magic-scale spinning ^{13}C NMR spectra have been obtained on oil shales representing a variety of geologic ages, origins, depositional environments, and source locations. The spectra show variations in the aliphatic and aromatic carbon distributions of the oil shales and reveal correlations between aliphatic carbon contents and potential shale oil yields. Hints of additional fine structure are present in the spectra of some samples, and examples are given of the spectral resolution that may be obtainable on other solid samples of geochemical interest.

364 PERMITTIVITY OF OIL SHALE, REVISITED. Judzis, A. Jr. (Univ of Mich, Ann Arbor). Int. J. Rock Mech. Min. Sci. Geomech. Abstr.; 16: No. 3, 221-222(Jun 1979).

The dielectric behavior of Green River oil shale from the Piceance Creek Basin in Colorado was studied, using low power microwave radiation. The imaginary term of the complex relative dielectric constant correlates well with organic richness. Impact of this result on assaying oil shales is far-reaching, enabling substantially faster analyses for potential oil yields than the standard Fischer assay, with possibilities for actual field or in-situ organic measurement.

365 REACTION KINETICS BETWEEN CO;SUB 2; AND OIL-SHALE RESIDUAL CARBON--1. EFFECT OF HEATING RATE ON REACTIVITY. Burnham, A.K. (Univ of Calif, Lawrence Livermore Lab). Fuel; 58: No. 4, 285-292(Apr 1979).

In this paper, the first part of an investigation of the reactivity of oil-shale residual carbon is reported. The reaction kinetics of CO;sub 2; with oil-shale residual carbon were measured using both isothermal and nonisothermal methods. The effect of the heating rate in the retort on the subsequent reactivity of the residual carbon was examined. Surface area and mercury porosimetry results are presented in an attempt to explain this difference in reactivity.

366 DETERMINATION OF TRACE ELEMENTS IN LIGHT ELEMENT MATRICES BY X-RAY FLUORESCENCE SPECTROMETRY WITH INCOHERENT SCATTERED RADIATION AS AN INTERNAL STANDARD. Giauque, R.D.; Garrett, R.B.; Goda, L.Y. (Univ. of California, Berkeley). Anal. Chem.; 51: No. 4, 511-516(Apr 1979).

A method for the direct determination of trace elements in light element matrices is described. It takes advantage of the fact that the incoherent mass scattering coefficient for 17.4 keV Mo Kα radiation is relatively constant for the elements Li(Z = 3) + Ca (Z = 20). Consequently, incoherent scattered Mo Kα excitation radiation, corrected for matrix absorption, can serve as an internal standard which compensates for variations in sample mass, x-ray tube output, and sample geometry. Samples of approx. 0.5 g are prepared in the form of thin specimens (approx. 0.08-cm thick) in a cell between two 0.0006-cm thick polypropylene windows. Standardization for most elements is achieved using standard aqueous solutions diluted to approx. 100 ppM. Data obtained from simultaneous transmission measurements for several x-ray energies are used to calculate matrix absorption corrections. For 15-min analysis periods, results are typically accurate to within +-10% when x-ray counting statistics are not the limiting factor. Sensitivities of 2 ppM or better are realized for 16 of the 22 elements determined (Ti + Zr, Hg, Pb, Th, and U). 7 figures, 7 tables.

367 TEMPERATURE AND STRESS DEPENDENCE OF ELECTRICAL AND MECHANICAL PROPERTIES OF GREEN RIVER OIL SHALE. Nottenburg, R.N.; Rajeshwar, K.; Rosenvold, R.J.; Dubow, J.B. (Colo State Univ, Fort Collins). Fuel; 58: No. 2, 144-148(Feb 1979).

Simultaneous measurements of the variation in the electrical and mechanical properties with stress and temperature have been carried out on Green River oil shale. The results of the present study reveal the presence of a structural transition at 380;degree;C; this temperature also corresponds to the structural yield point of the shale. Changes in the mechanical strength of the shale at temperatures corresponding to its yield point are accompanied by corresponding sharp variations in its electrical resistivity. The loss in mechanical strength at the yield point is found to be directly proportional to the amount of organic matter in the shale. The structural transition at the yield point is absent in the second heating cycle; electrical and mechanical measurements on reheated shale samples show clearly the irreversible nature of this transition. 14 refs.

368 ONLINE MEASUREMENTS OF THE FAST CHANGING DIELECTRIC CONSTANT IN OIL SHALE DUE TO HIGH-

POWER MICROWAVE HEATING. Hu, C.J. (Univ of Colo, Boulder). IEEE Trans. Microwave Theory Tech.; MTT-27: No. 1, 38-43(Jan 1979).

The change of the complex dielectric constant of oil shale under intensive microwave heating is an abrupt phenomenon which is quite different from that due to conventional heating. Based on the principle of competitive chemical kinetics, a theory is proposed for explaining this rapid change of the dielectric constant. A mathematical analysis of a coaxial waveguide loaded with oil-shale blocks which has a fast changing dielectric constant with respect to time is carried out in detail, from which an online measuring technique is derived for measuring this fast changing dielectric constant with respect to time and temperature. Preliminary experimental results show that the proposed theory is suitable for explaining this fast changing phenomenon. The online measuring technique reported is very similar to the three-probe or five-port measuring methods reported in the literature, except that it is more general compared to some of these methods. Its designing approach is also different because it is derived from amodified phasor analysis with the physical picture easily visualized. 13 refs.

369 TRACE ELEMENT VARIATIONS IN AN OIL-SHALE RETORTING OPERATION. Wildeman, T.R. (Colorado School of Mines, Golden); Heistand, R.N. Am. Chem. Soc., Div. Fuel Chem., Prepr.; 24: No. 1, 271-280(1979). (CONF-790415--P2).

From 177. national meeting of the American Chemical Society; Honolulu, HI, USA (1 Apr 1979).

The first conclusion that appears from the results is that the oil yield measurably changed from day to day. The percent of variance is 63% for the daily level. The oil yield is a reasonable measure of the organic content of the shale. The elemental concentration results are quite interesting. A geochemist would expect concentration ranges for trace elements to range by about a factor of 10 over a section of a formation. Here the range is only a factor of 2. For some elements like Rb and Sr, the relative standard deviation over all the samples is less than 10%. For most of the elements, the analytical precision is at 10% or less. This can be considered to be quite respectable for a multi-element analytical technique. Nevertheless, for Ca, Mn, Fe, Cu, and Se the analytical precision contributes most of the error as can be seen by the percent of variance for the analysis for these elements. The contrast in conclusions for the organic and inorganic portions is obvious. Since great care was taken in sampling design, one has to conclude that this difference is real. Several implications arise from this organic and inorganic difference. The primary conclusion is that on a production level none of the inorganic elements vary in the same general way as the organic content of the oil shale. Another implication of this dicotomy is that the results of analyses on the organic content which would typically be performed by an oil analysis laboratory will not yield information about the inorganic elements. This implication means that specific analyses for the inorganic elements will have to be made if their concentrations are of interest.

370 AROMATIC NITROGEN COMPOUNDS IN FOSSIL FUELS: A POTENTIAL HAZARD. Ho, C.H.; Clark, B.R.; Guerin, M.R.; Ma, C.Y.; Rao, T.K. (Oak Ridge National Lab., TN). Am. Chem. Soc., Div. Fuel Chem., Prepr.; 24: No. 1, 281-291(1979). (CONF-790415--P2).

From 177. national meeting of the American Chemical Society; Honolulu, HI, USA (1 Apr 1979).

The nitrogen content either of shale oil (1 to 2%) or coal derived oil (1 to 1.5%) is far higher than that in petroleum (average N-content in petroleum is 0.05 to 0.1%). This means enormous amounts of nitrogen containing species will be produced and found in crude synfuels, and this could lead to significant health or environmental impact. Clearly, a thorough characterization of nitrogen compounds in synfuels is an important pursuit. Aromatic nitrogen compounds such as basic aza-arenes, neutral aza-arenes, and aromatic amines are considered environmentally important and several members of these classes of compounds possess biological activity. For example, dibenz(a,h)acridine, 7 H-dibenzo(c,g)carbazole, and 2-naphthylamine, are well known as carcinogens. In this paper, the methods used to isolate the basic aromatic nitrogen compounds and neutral aza-arenes from one shale oil and one coal-derived oil are discussed. The mutagenic activities of these fractions, based on the Ames Salmonella typhimurium test is compared. The acetone subfracion of shale/oil was about half as mutagenic as benzo(a)-pyrene while the coal-derived oil subfraction was about four times more active. GC/MS data indicate multi-ring aza-arenes comprised a large portion of the acetone subfraction, e.g. aza-benzoperylene, aza-indenopyrene, and aza-coronene have been identified. The presence of aromatic amines in the active subfraction from both oil samples was first suggested from their IR spectra. This finding may mean that the primary aromatic amines as well as multi-ring aza-arenes are producing the mutagenic activities of the acetone subfractions. A logical extension of this work is to further separate the acetone subfraction into primary amines and multi-ring aza-arenes. This should lead to some important conclusions regarding the mutagenic effects of these classes of compounds.

371 MEASUREMENT OF THERMAL CONDUCTIVITY OF GREEN RIVER OIL SHALES BY A THERMAL COMPARATOR TECHNIQUE. Nottenburg, R.; Rajeshwar, K.; Rosenvold, R.; DuBow, J. (Colo State Univ, Fort Collins). Fuel; 57: No. 12, 789-795(Dec 1978).

A thermal comparator method has been developed for the measurement of the thermal conductivity of oil shales from the Green River formation. Oil shales from two locations in the above formation were studied. Measurements were carried out in the temperature range 25-350°C on oil shales. A simple model is proposed to explain the anisotropic effects observed in the thermal-conductivity values for heat flowing in directions parallel and perpendicular to the shale bedding planes.

372 HETEROAROMATIC MOIETIES IN GREEN RIVER OIL SHALE KEROGEN. Bugle, R.C.; Osteryoung, R.A. (Colorado State Univ., Fort Collins). Org. Geochem.; 1: No. 2, 109-113(Dec 1978).

Investigation of the reaction of Green River oil shale kerogen with sodium borohydride in trifluoroacetic acid by infrared spectroscopy has shown the appearance of absorptions representative of lactams. These lactams can be shown to have possible precursors that are heteroaromatic in composition and as such could demonstrate the existence in Green River kerogen of aromatic nitrogen compounds.

373 EXPERIMENTAL METHOD TO ESTIMATE THE DYNAMIC FRACTURE STRENGHT OF OIL SHALE IN THE 10^3 TO $10^4 S^{-1}$ STRAIN RATE REGIME. Forrestal,

M.J.; Grady, D.E.; Schuler, K.W. (Dept. of Energy, Washington, DC). Int. J. Rock Mech. Min. Sci. Geomech. Abstr.; 15: No. 5, 263-265(Oct 1978).

A magnetic pressure loading technique was successfully applied to estimate the dynamic spall strength of oil shale in the 1 to 3 x 10^3 sec^{-1} strain rate regime. (JSR)

374 OIL-SHALE KEROGEN: LOW TEMPERATURE DEGRADATION IN MOLTEN SALTS. Bugle, R.C.; Wilson, K.; Olsen, G.; Wade, L.G. Jr.; Osteryoung, R.A. (Colorado State Univ., Ft. Collins). Nature (London); 274: No. 5671, 578-580(10 Aug 1978).

From results on cholesterol and other model systems, the following process apparently takes place when Green River kerogen is placed in a basic tetrachloroaluminate melt. Initially, hydrogen cations form which subsequently recombine with excess chloride, producing hydrogen chloride gas which escapes from the melt. The kerogen radicals formed can abstract labile hydrogen from another part of the kerogen macromolecule. These recombinations continue as free hydrogen cations and recombine with chloride resulting in an increase in the aromatic character while the macromolecule's size reduces from the various splittings which can occur. It is believed it is this mechanism involving a mode of free radical intramolecular disproportionation combined with the ability of the melt to permeate the inorganic matrix of the shale which results in the ability to extract soluble organic material from Green River kerogen.

375 IDENTIFICATION OF ISOPRENOIDS, STERANES, AND TERPANES IN FISCHER ASSAY RETORTED SHALE OILS. Morandi, J.R.; Guffey, F. (Laramie Energy Res Cent, Wyo). Am. Chem. Soc., Div. Fuel Chem., Prepr.; 23: No. 1, 228-239(12 Mar 1978).

In the past 15 years much work has been done on the identification of individual compounds in the branched-plus-cyclic paraffin hydrocarbon fractions from Green River oil shale bitumens. Most of the geochemical studies have been made on the unpyrolyzed bitumen because of the suspicion that pyrolysis of the kerogen would destroy or alter the biological markers and thus negate the results. However, recent studies suggest that some of these markers survive pyrolysis. In the reported study, saturate fractions of Fisher assay oils from an earlier study were examined in detail to see if the biological markers survive the retorting process. Experimental data are presented which show that the biological markers identified include isoprenoid alkanes, monocyclic terpanes, steranes, and pentacyclic triterpanes. These are the same classes of compounds that have been identified in extracted bitumen and pyrolyzed oil shale. It is postulated that both the material from extracted bitumen and the product oil should be investigated for a more complete geochemical picture of oil shale formation. 16 refs.

376 AROMATIC AND ALIPHATIC CARBON CONTENTS OF COALS AND OIL SHALES BY ^{13}C NMR. Maciel, G.E. (Colorado State Univ., Fort Collins); Bartuska, V.J.; Miknis, F.P. Am. Chem. Soc., Div. Fuel Chem., Prepr.; 23: No. 4, 120-123(1978). (CONF-780902--P2).

From American Chemical Society meeting; Miami, FL, USA (10 Sep 1978).

From ^{13}C nmr spectra quantitative determinations of aromatic/olefinic and aliphatic carbon contents can be made. However, many questions must be raised to determine the reliability of this approach for quantitative analytical purposes. These questions revolve largely about the dynamics of the experiment, i.e., the characteristic relaxation times of the pertinent processes. The essential question is: can experimental conditions and corrections be found so that all organic carbon types are ''counted'' equally in the ^{13}C experiment. Many experiments have been carried out to characterize the conditions for typical coals and oil shales, so that optimized experiments could be designed. Comparisons with experiments carried out with high-power ^{1}H decoupling, but without ^{13}C-^{1}H cross polarization, are essential for assessing the efficiency and deviations from uniformity of the cross polarization process. One key feature of calibrating the ^{13}C approach so that absolute aromatic/olefinic or aliphatic carbon contents can be determined is an external ^{13}C standard. The requirements for an external standard involve both the chemical shift (to avoid critical peak overlaps) and relaxation times (to avoid intensity distortions). With a method capable of determining aromatic/olefinic and aliphatic carbon contents, various comparisons and correlations are possible. These include comparisons among related samples (e.g., oil shale and shale oil; coal and solvent-refined coal or hydrogenated coal), and correlations with pertinent fuel parameters, e.g., gal/ton obtained from oil shale or Btu/ton for coal or oil shale.

377 ORGANIC STRUCTURE STUDIES OF FOSSIL FUELS BY NUCLEAR MAGNETIC RESONANCE. Bartuska, V.J. (Colorado State Univ., Ft. Collins); Maciel, G.E.; Miknis, F.P.; Netzel, D.A. Am. Chem. Soc., Div. Fuel Chem., Prepr.; 23: No. 4, 132-137(1978). (CONF-780902--P2).

From American Chemical Society meeting; Miami, FL, USA (10 Sep 1978).

Using ^{13}C solid-sample techniques the total organic proton content can be determined along with the aromatic/olefinic and aliphatic carbon contents of the raw shale, of the solid remaining after bitumens are extracted, of the solid kerogen concentrate obtained from the shale, and of the residue from retorted shale. Using standard Fourier transform techniques for liquids, analogous information and considerably greater structural detail can be obtained on the bitumens extracted from the shale and on the shale oil retorted from the shale. In interpreting the intensities of the resonance of such carbon spectra, attention must be directed to intensity distortions associated with nuclear Overhauser effects and the dynamics of the cross polarization experiment.

378 FATIGUE TESTS OF OIL SHALE. Chang, B. (Univ. of Wyoming, Laramie); Costello, K.; Chong, K.P.; Smith, J.W. pp 408-413 of Rock mechanics. Kim, Y.S. (comp.). Reno, NV; University of Nevada (1978).

From 19. symposium on rock mechanics; Lake Tahoe, NV, USA (1 May 1978).

This article deals with the influence of cyclic loading on Tipton Member oil shale. Effects of organic content on endurance limits are discussed. In addition combined effects or orgainc content and stress levels on the number of cycles before faiure are presented.

379 CREEP AND RELAXATION OF OIL SHALE. Chong, K.P. (Univ. of Wyoming, Laramie); Smith, J.W.; Khaliki, B.A. pp 414-418 + vp of Rock mechanics. Kim, Y.S. (comp.). Reno, NV; University of Nevada (1978).

From 19. symposium on rock mechanics; Lake Tahoe, NV, USA (1 May 1978).

This paper presents results of a study on the creep and relaxation behavior of oil shale. The set of duplicate test specimens required for creep testing were cut from a single oil shale layer using a wire saw to avoid any surface damage. A rheological model was developed for creep and relaxation behavior of oil shale as a function of stress level and organic content. Data from creep testing together with x-ray and Fischer assay analyses were used to demonstrate correlation between various stress levels and organic contents for samples of Wyoming Green River Formation.

380 SAPONIFICATION OF THE INSOLUBLE ORGANIC RESIDUES FROM OIL SHALES, ALGAL OOZES, AND ALGAE. Philp, R.P.; Brown, S.; Calvin, M. (Univ of Calif, Berkeley). Energy Sources (N.Y.); 4: No. 2, 113-123(1978).

This paper describes results from saponifying residues of some blue-green and green algae, two algal oozes, and for the sake of comprison, kerogen from the Green River oil shale. The major aim of these experiments was to obtain information on any components linked as esters to the kerogen-like residues. The minor aim was to see whether there were any variations in the saponification products which could be linked to sructural variations in the residues. In general the products from the organisms were dominated by n-C_{16} and n-C/sub 18:1/ fatty acids and in the case of a green alga, Chlorella pyrenoidosa, α, ω-dicarboxylic acids in the range C_8-C_{11}, along with very minor amounts of isoprenoid acids. These products showed some similarities with those obtained from saponification of the ancient kerogen which was dominated by α, ω-dicarboxylic acids.

381 FREE LIME IN RETORTED OIL SHALE. Heistand, R.N.; Jones, D.B.; Morriss, L.L. (Dev Eng, Inc, Rifle, Colo). Energy Sources (N.Y.); 4: No. 2, 195-202(1978).

Free lime (as CaO) was determined on retorted shale which had been heated in air at 1200°F, 1300°F, and 1400°F at times ranging from one-half hour to eight hours. A.S.T.M. Standard C-114 was used to measure free lime on samples sealed from air while hot. No interference was noted from magnesia or other materials occurring in retorted shale. Free lime was found to increase with heating time and then decrease upon continued heating after reaching a maximum. Solid-state reactions consuming calcium oxide and forming complex silicates or aluminates are thought to occur producting qualities of low-grade cements in shale retorted under certain conditions. X-ray diffraction data on the same samples confirm this conclusion. Special management of shales retorted under controlled conditions would produce maximum cementation, thus minimizing erosion and leaching of retorted shales.

382 CATALYSIS ON THE ATOMIC SCALE (EMMETT AWARD LECTURE OF 1977). Somorjai, G.A. (Univ. of California, Berkeley). Catal. Rev. - Sci. Eng.; 18: No. 2, 173-197(1978).

This lecture demonstrates how recent advances made by modern surface chemistry influence the source of heterogeneous catalysis. Various selected techniques for surface studies on the atomic scale are discussed. A partial list of these techniques is outlined in tabular form. Four important surface phenomena, all major ingredients of heterogeneous catalysis that have been placed on a firmer foundation by the modern atomic scale studies are (1) the catalyst surface is heterogeneous, (2) reconstruction of the catalyst under the reaction conditions, (3) the catalyst surface is covered with a near monolayer deposit under most reaction conditions, and (4) additives or promoters is partly responsible for the surface chemistry of the catalytic system. With the basic knowledge of the character of the active catalyst on the atomic scale, improving the selectivity or optimizing the activity of catalysts is proably directions for future research. Studies of monolayer systems of metals on oxides or on metals of other types should yield new synthetic catalytic systems. (BLM)

383 CHARACTERIZATION DATA FOR SYNCRUDES AND THEIR IMPLICATION FOR REFINING. Dooley, J.E.; Lanning, W.C.; Thompson, C.J. (Bartlesville Energy Research Center, OK). Am. Chem. Soc., Div. Pet. Chem., Prepr.; 22: No. 3, 904-910(Aug 1977). (CONF-770301--P3).

From 173. national meeting of the American Chemical Society; New Orleans, LA, USA (20 Mar 1977).

A recent survey of literature suggests that a given rank of coal can be correlated with the types of hydrocarbons that can be obtained upon liquefaction. BERC is making a systematic study designed to provide samples of liquid products from coals which vary widely in rank and quality and from oil shale. The liquids so obtained will undergo characterization using BERC procedures, and the data will be used to supplement the characterization studies in progress on other syncrudes. A preliminary report is made here on the progress of this work.

384 COMPREHENSIVE THERMODYNAMIC STUDIES OF SEVEN AROMATIC HYDROCARBONS. Finke, H.L.; Messerly, J.F.; Lee, S.H.; Osborn, A.G.; Douslin, D.R. (Bartlesville Energy Research Center, OK). J. Chem. Thermodyn.; 9: 937-956(1977).

Heat capacity and enthalpy of transition were measured for phenanthrene, acenaphthene, fluorene, 1,2'-dinaphthylmethane, 1,8-,2,6-, and 2,7-dimethylnaphthalene from 10 to about 440°K in order to provide experimental data for deriving the following thermodynamic quantities over a range of temperature of the condensed phases and the perfect gas state: [H/sub s2(T) - H°(0)], [S/sub s/(T) - S(0)], C/sub s/, [H°(T) - H°(0)], S°, ΔH°/sub f/, ΔS°/sub f/, ΔG°/sub f/, and $\log_{10}$K°/sub f/. Experimental values for the condensed states were converted to gaseous-state values with the aid of enthalpies of vaporization derived from vapor pressures and the Clapeyron equation. Linear relations of ΔG°/sub f/ against T were used to extrapolate to standard values at 298.15 K. (3 figures, 7 tables)

385 ELECTRICAL AND THERMAL TRANSPORT PROPERTIES OF GREEN RIVER OIL SHALE HEATED IN NITROGEN. Dubow, J.; Nottenburg, R.; Rajeshwar, K.; Rosenvold, R. (Colorado State Univ., Fort Collins). pp 60-73 of Tenth oil shale symposium proceedings. Reubens, J.B. (ed.). Golden, CO; Colorado School of Mines (1977).

From 10. oil shale symposium; Golden, CO, USA (21 Apr 1977).

Thermal conductivity varies from 0.2 to 1.0 BTU/ft-hr-°F and tends to decrease with increasing temperature. The thermal diffusivity varies rom 0.2 to 0.45 ft^2/day and also tends to decrease with increasing temperature. Both thermal conductivity and thermal diffusivity decrease with increasing kerogen content. Dielectric constant, which measures electrical energy stored in the material, decreases with

increasing frequency. As temperature increases, dielectric constant initially decreases; then increases again, attaining values close to room temperature value. Loss tangent, a measure of electrical energy absorbed by the material, decreases with increasing frequency and increases with increasing temperature. At temperatures approaching the retorting temperature, a secondary peak appears in the loss tangent. This peak correlates with the onset of kerogen decomposition, as indicated by DTA. These data are indicative of potential applications as retort diagnostics and electrical heating and fracture processes. 11 figures, 1 table.

DIRECT USES AND BY-PRODUCTS

386 (CONF-780903--) PROCEEDINGS OF THE SYMPOSIUM ON POTENTIAL HEALTH AND ENVIRONMENTAL EFFECTS OF SYNTHETIC FOSSIL FUEL TECHNOLOGIES. (Oak Ridge National Lab., TN (USA)). Jul 1979. Contract W-7405-ENG-26. 293p. Dep. NTIS, PC A13/MF A01.

From Symposium on potential health and environmental effects of synthetic fossil fuel technologies; Gatlinburg, TN, USA (25 Sep 1978).

This symposium included five sessions. Session I dealt with the technology for contending with harmful effluents primarily from coal conversion processes. Session II was designed to address the need for the systematic application of existing capabilities to the collection and characterization of materials of importance to the life scientists. Session III had the underlying theme of the health effects research - biologists, chemists, and technologists working together to confront the problems of the emerging industries. Session IV provided the most recent data in the areas of atmospheric, solid, and liquid releases. Session V dealt with effects on humans and on those people who may potentially be affected by the toxic material that they produce. In summary, the sessions were: technology, chemical, characterization, biological effects, environmental and ecological effects and occupational health effects. 29 pages were included.

387 (CONF-7710101--12) NAHCOLITE PROPERTIES AFFECTING STACK GAS POLLUTANT ABSORPTION. Howatson, J.; Smith, J.W.; Outka, D.A.; Dewald, H.D. (Wyoming Univ., Laramie (USA); Department of Energy, Laramie, WY (USA). Laramie Energy Technology Center). 1977. 6p. Dep. NTIS, PC A02/MF A01.

From 5. national conference on energy and the environment; Cincinnati, OH, USA (31 Oct 1977).

Nahcolite, the mineral form of sodium bicarbonate, is present in vast quantities in Green River Formation oil shales of Northwestern Colorado. The total resource is about 29 billion tons. Nahcolite is being seriously considered as an SO_2 and NO/sub x/ absorber for coal-fired power plants. In this application it decomposes to sodium carbonate (with loss of carbon dioxide and water) which then reacts with SO_2 and NO/sub x/ in the flue gas stream. This paper deals with characteristics of the mineral and its solid decomposition product which are important in the absorption of these gaseous pollutants. These include some aspects of thermal decomposition of the nahcolite as well as information about the physical nature of the sodium carbonate produced. Data on pore size, pore distribution, surface area and compressive strength are presented. Four common types of nahcolite were investigated. Thermal decomposition of nahcolite at flue gas temperatures produces porous sodium carbonate with high surface area capable of reacting rapidly and efficiently with SO_2 and NO/sub x/. All four types of nahcolite showed suitable properties.

388 (CONF-7810176--, pp 25-44) ALTERNATIVE FUELS UTILIZATION PROGRAM. Fleming, R.D. (Department of Energy, Washington, DC). Jun 1979.

From Conference on composition of transportation synfuels: R and D needs, strategies and actions; San Antonio, TX, USA (11 Oct 1978).

A DOE program to extend and replace petroleum with synthetic fuels from oil shale and coal could prevent serious disruptions when domestic petroleum reserves are depleted. DOE's plan is to lower the uncertainty costs of using alternative fuels. Five fuel categories under consideration are, in order of priority: new hydrocarbons, alcohols, synfuels, advanced fuels, and emergency fuels. Only new hydrocarbons and synfuels are addressed in detail here, the programmatic aspects of the other three stated very briefly. The objectives related to these fuels and the strategies planned for attaining these objectives are described. The project work flow plan is based on a matrix progression from problem definition to large-scale adaptation. Four major factors - process technology assessment, fuel properties and composition, engine-vehicle characterization, and systems studies of the socio-economic, environmental, and institutional factors - are considered in terms of resource-through-end-use.

389 (CONF-7810176--, pp 283-310) COMPOSITION AND PERFORMANCE OF PARAHO SYNFUELS. Robinson, E.T. (Standard Oil Co., Warrensville, OH); Kunchal, S.K. Jun 1979.

From Conference on composition of transportation synfuels: R and D needs, strategies and actions; San Antonio, TX, USA (11 Oct 1978).

Pilot plant studies on shale oil-derived fuels are reported by the Standard Oil Company of Ohio. A series of charts and graphs summarizes the results of PARAHO shale oil analyses, shale oil refining process, hydrotreating, and the composition and stability fo shale-derived fuels. The conclusions drawn from this information are that: (1) a settling pre-treatment, guard-bed to protect the catalyst, hydrotreating, and acid/clay treating are all required; (2) hydrotreated shale oil can produce yields of six percent gasoline, 24% jet fuel, 35% diesel fuel marine, and 35% heavy fuel oil; and (3) it is possible to produce specification military fuels.

390 (CONF-7810176--, pp 355-377) MEANS TO STIMULATE R and D ACTIONS: WORKSHOP. Parker, A.J. Jr. (Mueller Associates, Inc., Baltimore, MD). Jun 1979.

From Conference on composition of transportation synfuels: R and D needs, strategies and actions; San Antonio, TX, USA (11 Oct 1978).

Positive suggestions are elicited for research and development on synthetic transportation fuels from coal and oil shale. The moderator notes that the fuel makers were having more input into the conference than the fuel users and that this imbalance could lead to frustrations unless the fuel users' silence reflects the lack of a problem. He sees a

general consensus among participants that research is needed on fuel specifications, combustion characteristics, scale-up problems, and refinery organization. He questions the need for a systems approach and whether economics should not be a consideration in oil-shale development. Twenty speakers participated in the ensuing discussion of these and other issues. Concern was expressed that technical experts are not communicating effectively with the public.

391 (UCRL-13886(Pt.2)) ECONOMICS AND MODELING OF MANUFACTURE AND AUTOMOTIVE USE OF BROAD-CUT FUELS FROM COAL AND SHALE SYNCRUDES. Moore, M.A.; Short, W.D. (SRI International, Menlo Park, CA (USA)). Aug 1978. Contract W-7405-ENG-48. 40p. Dep. NTIS, PC A03/MF A01.

SRI has developed the pertinent economic and efficiency data on the manufacture, distribution, and end-use of broad-cut fuels (BCF) for automotive transportation. This study defines the economic parameters of refining BCF from syncrude and chooses an appropriate modeling approach to represent this potential fuel option for transportation. A number of engines have been developed that can use wide boiling range fuels (BCF) without the octane, cetane, and other qualities now required in gasoline and diesel fuels. For this study, Texaco's design for a direct-injected stratified charge (DISC) engine has been selected to represent the generic class of BCF engines. This engine's technology will allow considerable simplification of the refinery processing required for automotive fuel, with corresponding reductions in refinery energy requirements and operating costs. The BCF under consideration is envisioned to be a mixture of hydrocarbons in the nominal distillation temperature range of 100 to 650°F. Many conventional petroleum products, including gasoline, kerosene, and diesel fuel, lie within this boiling range. Once separated from the syncrude mixture, the BCF fraction is conceived to require no additional processing other than hydrotreating to remove sulfur, nitrogen, and oxygen heteroatoms remaining from the syncrude upgrading stage. Thus, the refinery process required for this minimal chemical modification of the syncrude product could be as simple as a conventional atmospheric distillation step followed by hydrotreating of the 650°F and lighter fractions.

392 USE OF OIL SHALE FOR CONTROL OF SULFUR DIOXIDE EMISSIONS FROM THE COMBUSTION OF COAL. Fuchs, L.H.; Nielsen, E.L.; Hubble, B.R. (Argonne National Lab., IL). Thermochim. Acta; 26: No. 1-3, 229-239(Oct 1978).

From 7. North American Thermal Analysis Society conference; St. Louis, MO, USA (25 Sep 1977).

Experimental results have been obtained which indicate that oil shale from the Mahogany ledge of the Green River formation (28 gal oil/ton) has short-term (less than or equal to 3 h) sulfation properties superior to those of 1337 dolomite and consequently could be used more effectively to control SO_2 emissions from the combustion of coal. In a gas mixture containing 0.27 percent SO_2, the initial sulfation reaction rate at 750°C for the half-calcined shale is nearly six times that for the half-calcined dolomite. After 3 h, all of the $CaCO_3$ in the half-calcined shale is sulfated, compared with only 37 percent in an equal amount of half-calcined dolomite. Although the results were obtained on spent shale (kerogen removed), they suggest that raw shale might be used for emission control in fluidized-bed combustors to derive an added benefit from the heat content of the shale.

393 EXPERIMENTAL RESULTS FROM AN 0.46 M-DIAMETER FLUID BED PILOT PLANT. (Foster Wheeler Dev Corp, John Blizard Res Cent, Livingston, NJ). pp 258-263 of Fluidization. Taylor, T.E. New York, NY; Cambridge Univ. Press (1978).

From Conference on fluidization; Cambridge, UK (1 Apr 1978).

A series of combustion tests was carried out in an 0.46 m fluid bed combustor to determine the feasibility and operating characteristics of a variety of solid fuels. Once-through combustion efficiencies were found to range from 80% while firing coke breeze, to greater than 99% with oil shale. Carbon carry-over recycle produced significant improvements in combustion efficiency. Test of overbed fuel feeding produced results consistent with in-bed feed data.

HEALTH AND SAFETY

394 (BNL--51002) PROCEEDINGS OF THE SYMPOSIUM ON ASSESSING THE INDUSTRIAL HYGIENE MONITORING NEEDS FOR THE COAL CONVERSION AND OIL SHALE INDUSTRIES. White, O. Jr. (ed.). (Brookhaven National Lab., Upton, NY (USA)). Mar 1979. Contract EY-76-C-02-0016. 333p. (CONF-781150--). Dep. NTIS, PC A15/MF A01.

From Symposium on assessing the industrial hygiene monitoring needs for the coal conversion and oil shale industries; Upton, NY, USA (5 Nov 1978).

This work was supported by the United States Department of Energy, Division of Biomedical and Environmental Research, Analysis and Assessment Program, through the Safety and Environmental Protection Division at Brookhaven National Laboratory. The symposium program included presentations centering around the themes: Recognition of Occupational Health Monitoring Requirements for the Coal Conversion and Oil Shale Industries and Status of Dosimetry Technology for Occupational Health Monitoring for the Coal Conversion and Oil Shale Industries. Sixteen papers have been entered individually into EDB and ERA; six had been entered previously from other sources. (LTN)

395 (BNL--51002, pp 97-105) LASL INDUSTRIAL HYGIENE EXPERIENCES IN THE OIL SHALE INDUSTRY. Garcia, L.L. (Los Alamos Scientific Lab., NM). Mar 1979.

From Symposium on assessing the industrial hygiene monitoring needs for the coal conversion and oil shale industries; Upton, NY, USA (5 Nov 1978).

Various facets of the Paraho Process are discussed. An industrial hygiene survey of the facilities for retorting oil by the Paraho Process at Anvil Points was planned but not completed. Suggestions for future surveys are made. (JGB)

396 (BNL--51002, pp 273-287) SCREENING TECHNIQUES FOR BIOLOGICAL ACTIVITY. Daisey, J.M.; Mukai, F. (New York Univ. Medical Center, NY). Mar 1979.

From Symposium on assessing the industrial hygiene monitoring needs for the coal conversion and oil shale industries; Upton, NY, USA (5 Nov 1978).

Some of the in vitro bioassays which are presently available for monitoring industrial environments are discussed, and their applicability to the evaluation of occupational

exposures in the coal conversion and shale oil industries are considered. As no direct assessment of the degree of human hazard can be made from the results of such tests, the choice of appropriate standards for comparison are discussed. The advantages and limitations of such systems are considered, and research needs for the application of industrial monitoring are suggested.

397 (BNL--51002, pp 153-171) CRITERIA FOR OCCUPATIONAL HEALTH MONITORING IN THE FOSSIL FUEL CONVERSION INDUSTRIES. White, O. Jr. Mar 1979.

From Symposium on assessing the industrial hygiene monitoring needs for the coal conversion and oil shale industries; Upton, NY, USA (5 Nov 1978).

The focus of this paper is to provide the occupational health professional with a criteria that will assist in establishing priorities in occupational health monitoring programs for the synthetic fuel industries. Elements which must be considered in establishing monitoring criteria are as follows: identification of hazardous operations and processes; hazard classification of contaminants; identification of workforce members at high risk; total risk assessment involving all occupational safety and health hazards; and monitoring strategy.

398 (CONF-780903--, pp 129-136) SHORT-TERM MUTAGENICITY TESTING. Epler, J.L.; Ho, T.; Hsie, A.W.; Larimer, F.W.; Nix, C.E.; Rao, T.K. (Oak Ridge National Lab., TN). Jul 1979.

From Symposium on potential health and environmental effects of synthetic fossil fuel technologies; Gatlinburg, TN, USA (25 Sep 1978).

The major goal of the mutagenesis research group in the Biology Division at Oak Ridge National Laboratory is to provide a means of mutagenicity testing of those compounds produced by various existing or proposed methods of energy generation. These compounds include the primary effluents of existing fossil fuel sources such as sulfur dioxide, the oxides of nitrogen, ozone, hydrocarbons, and heavy metals, as well as products of newly proposed methodologies such as coal liquefaction and of auxiliary methodologies such as cooling-tower additives. The work is divided into two phases, one dealing with known compounds expected to occur in the environment through energy production, conversion, or use, and another dealing with actual samples from existing or experimental processes. To approach the problems of dealing with and the testing of large numbers of compounds, we set up a form of the tier system. Operating units utilizing Salmonella, E. coli, yeast, human leukocytes, mammalian cells, and Drosophila have been initiated. As a working list we have looked to those compounds expected to be used in fossil fuel production or conversion. Many of these compounds are polycyclic hydrocarbons and require metabolic activation with mammalian extracts. Basic and neutral fractions from crude oils are mutagenic in the microbial systems. Comparative studies with leukocytes, mammalian cells, and Drosophila validate these results. The assays represent rapid tests for potential biohazards. 5 tables.

399 (CONF-780903--, pp 157-162) TOXICOLOGY AND CARCINOGENIC INVESTIGATION OF SHALE OIL AND SHALE OIL PRODUCTS. Barkley, W. (Univ. of Cincinnati, OH); Warshawsky, D.; Suskind, R.R.; Bingham, E. Jul 1979.

From Symposium on potential health and environmental effects of synthetic fossil fuel technologies; Gatlinburg, TN, USA (25 Sep 1978).

The toxicity of several shale oils, produced by various retort methods, and spent shale samples is reported. A spent shale sample was studied for its teratogenic effects on rabbits. The benzo(a)pyrene content of these samples and other by-products was determined. The mouse skin bioassay technique was utilized to evaluate the carcinogenic potency of various shale oils and spent shale samples. 7 tables.

400 (CONF-780903--5) CARCINOGENICITY OF SYNCRUDES RELATIVE TO NATURAL PETROLEUM AS ASSESSED BY REPETATIVE MOUSE SKIN APPLICATION. Holland, J.M.; Whitaker, M.S.; Wesley, J.W. (Oak Ridge National Lab., TN (USA)). 1978. Contract W-7405-ENG-26. 16p. Dep. NTIS, PC A02/MF A01.

From Symposium on potential health and environmental effects of synthetic fossil fuel technologies; Gatlinburg, TN, USA (25 Sep 1978).

The relative carcinogenicities of coal and shale derived liquid crudes was compared with a composite blend of natural petroleum using discontinuous exposure of mouse skin. All of the syncrudes were carcinogenic while the natural crude composite was negative following three times weekly application of 50% w/v solutions for 22 wks followed by a 22 wk observation period. In addition to eliciting progressive squamous carcinomas the syncrudes were also capable of inducing persistent ulcerative dermatitis. This inflammatory or necrotizing potential appeared to be inversely proportional to the carcinogenicity of the material. A measure of the relative solubility of the materials in mouse skin was obtained by quantitation of native fluorescence in frozen sections of skin. There appeared to be a general, although non-quantitative association between fluorescence intensity in sebaceous glands and carcinogenicity in epidermal cells, however it will be necessary to examine a greater number of samples to establish such a correlation.

401 (CONF-781150--6) ADEQUACY OF CURRENT DOSIMETRY TOOLS FOR THE COAL CONVERSION AND OIL SHALE INDUSTRIES. Campbell, J.E.; Porter, W.E. (Oak Ridge National Lab., TN (USA)). 1978. Contract W-7405-ENG-26. 7p. Dep. NTIS, PC A02/MF A01.

From Symposium on assessing the industrial hygiene monitoring needs for the coal conversion and oil shale industries; Upton, NY, USA (5 Nov 1978).

The determination of personnel exposure to PNA's in the breathing zone is essential. At present, the NIOSH-recommended method may not be completely acceptable, but it is the best method available. Much work is presently being conducted on developing more sensitive analytical techniques for determination of PNA's. With the large errors that seem to be inherent in the sampling technique discussed, these more sensitive analytical methods may be of little value. The primary area of concern is the standardization and development of a good sampling technique to determine breathing zone, time-weighted average concentrations of potentially exposed workers in the coal conversion and shale oil industries.

402 (CONF-790334--10) BIOLOGICAL MONITORING OF OIL SHALE PRODUCTS AND EFFLUENTS USING SHORT-TERM GENETIC ANALYSES. Rao, T.K.; Epler, J.L.; Schmidt-Collerus, J.J.; Leffler, L.; Guerin, M.R. (Oak Ridge National Lab., TN (USA);

Denver Research Inst., CO (USA)). 1979. Contract W-7405-ENG-26. 18p. Dep. NTIS, PC A02/MF A01.

From Oil shale symposium; Denver, CO, USA (26 Mar 1979).

The long-term health hazards such as mutagenesis, carcinogenesis, and teratogenesis due to the exposure to crude shale oil, particulate pollutants, and the leachates from raw or spent shale constitute a major concern in the development of shale oil technology. In order to monitor such biological effects, we have applied short-term genetic analyses with the exemplary test materials. The Salmonella/microsomal activation system (Ames assay) was generally applicable but only upon chemical fractionation. The Stedman liquid-liquid extraction procedure or the Sephadex gel filtration (LH-20) technique were effectively utilized. Mutagenicity analyses with various crude oils and product water have revealed biological activity in the basic (aromatic amine fractions) or in the neutral (polyaromatic hydrocarbon fraction) fractions. Extracts and chromatographically isolated materials from raw and spent shale were subjected to mutagenicity studies. Mutagenic activity was noted and correlates with the biological activity of compounds that are either identified or predicted to occur in these materials. Comparison to other energy technologies and overall health hazard of the test materials are discussed.

403 (CONF-790415--31) SYNTHETIC FOSSIL FUEL TECHNOLOGIES: HEALTH PROBLEMS AND INTERSOCIETY COOPERATION. Gammage, R.B.; Turner, J.E. (Oak Ridge National Lab., TN (USA)). 1979. Contract W-7405-ENG-26. 24p. Dep. NTIS, PC A02/MF A01.

From 177. national meeting of the American Chemical Society; Honolulu, HI, USA (1 Apr 1979).

The potential health impacts of synthetic fossil fuel products are considered mainly in terms of complex and potentially carcinogenic mixtures of polynuclear aromatic (PNA) compounds. These components of oils and tars present an especially perplexing range of problems to those concerned with health protection. The nature of these problems, such as multifactorial exposure, are discussed within a framework of current and future standards to regulate human exposure. Some activities of government agencies, national laboratories, and professional societies are described. A case can be made for pooling the resources of these groups to achieve better solutions for assessing the acceptability of the various technologies and safeguarding human health.

404 (CONF-790447--2) CHEMICAL AND BIOLOGICAL FACTORS INFLUENCING THE SKIN CARCINOGENICITY OF FOSSIL LIQUIDS. Holland, J.M.; Whitaker, M.J.; Gipson, L.C. (Oak Ridge National Lab., TN (USA)). 1979. Contract W-7405-ENG-26. 29p. Dep. NTIS, PC A03/MF A01.

From Health implications of the new energy technologies; Park City, UT, USA (4 Apr 1979).

Synthetically derived petroleums, obtained from either oil shale or coal, are carcinogenic when applied to mouse skin. The fluorescence of these materials in sebaceous glands has been quantitated using microphotometry. Structural and compositional features of the skin may contribute to determine the localization and subsequent tissue clearance of carcinogenic hydrocarbons. The sebaceous gland and associated lipids have been demonstrated to serve as traps for PAH's and the relative amount of PAH deposited in sebaceous glands is significantly affected by the lipotropic nature of the vehicle. These observations are highly relevant to an assessment of the potential consequences of human occupational skin exposure to whole, undiluted hydrocarbon mixtures which may contain a variety of known carcinogenic PAH's. It is possible that short chain aliphatic and aromatic molecules which make up the bulk of the syncrude may have as great or greater impact upon delayed or cumulative biological effects as the relative amount of specific active compounds.

405 (COO--4758-1) SYNTHETIC CRUDE OILS CARCINOGENICITY SCREENING TESTS. QUARTERLY REPORT, OCTOBER 16, 1978--FEBRUARY 15, 1979. Calkins, W.H.; Deye, J.F.; King, C.F.; Hartgrove, R.W.; Krahn, D.F. (Du Pont de Nemours (E.I.) and Co., Wilmington, DE (USA)). 1979. Contract EP-78-C-02-4758. 23p. Dep. NTIS, PC A02/MF A01.

Four crude oils (Southern Louisiana Crude Petroleum, H. Coal Syncrude, Paraho Crude Shale Oil, and Geokinetics in situ Shale Oil) have been distilled into four fractions (naphtha, mid-distillate, gas oil, and residue) for analysis and biological (mutagenicity and carcinogenicity) screening testing. Results of selected analytical tests have been obtained on the original crude oils and the fractions. Ames tests and initiation/promotion tests have been started on the original crude oils and the fractions. Four additional synthetic crude oils (Exxon EDS, SRC II, H Coal Fuel Oil, and Occidental In Situ Shale Oil) are being obtained for a second similar series of tests to be started in approximately four months.

406 (LA--7254-PR) BIOMEDICAL AND ENVIRONMENTAL RESEARCH PROGRAM OF THE LASL HEALTH DIVISION. PROGRESS REPORT, JANUARY--DECEMBER 1977. Petersen, D.F.; Sullivan, E.M. (comps.). (Los Alamos Scientific Lab., NM (USA)). Oct 1978. Contract W-7405-ENG-36. 201p. Dep. NTIS, PC A10/MF A01.

The report summarizes research and development activities of LASL's Biomedical and Environmental Research Program for the calendar year 1977. The principal features of the program have been carried out by groups in the Health Division, supported by the Assistant Secretary for the Environment of the United States Department of Energy. Previous annual reports in this series prepared under the auspices of the United States Atomic Energy Commission and the United States Energy Research and Development Administration are LA-4923-PR (1971), LA-5227-PR (1972), LA-5633-PR (1973), LA-5883-PR (1974), LA-6313-PR (1975), and LA-6898-PR (1976). Technical information related to the current status of projects in the major program areas of each contributing group is presented in sufficient detail to permit the informed reader to assess scope and significance and to obtain specific information from the publications listed in Appendix A. Summaries useful to the casual reader desiring general information have been prepared by the Group Leaders and appear at the beginning of each section of the report. Separate entries were made for various sections of the report.

407 (LA--7967-MS) ACUTE TOXIC EFFECTS OF TWO CRUDE SHALE OILS AND TWO STANDARD PETROLEUM CRUDE OILS APPLIED TO MOUSE SKIN. Wilson, J.S.; Holland, L.M. (Los Alamos Scientific Lab., NM (USA)). Aug 1979. Contract W-7405-ENG-36. 6p. Dep. NTIS, PC A02/MF A01.

The acute dermal toxicity of two crude shale oils and two crude petroleums was studied, in

an effort, to establish threshold tolerance levels for use in a subsequent epidermal carcinogenesis experiment. Five dose levels of each test oil were applied daily to the skin of C3Hf/He mice for two weeks. At the end of the two week treatment period all mice were humanely sacrificed and histological sections of the skin were examined for inflammatory changes. Representative tissues from major organ systems were also examined for signs of systemic toxicity. Neither of the reference petroleum crude oils caused severe inflammation, while both shale oils caused marked inflammation accompanied by ulceration at the higher dose levels.

408 (LA--7983-PR) DETECTION OF EARLY CHANGES IN LUNG CELL CYTOLOGY BY FLOW-SYSTEMS ANALYSIS TECHNIQUES. PROGRESS REPORT, JANUARY 1-JUNE 30, 1979. Steinkamp, J.A.; Wilson, J.S.; Svitra, Z.V. (Los Alamos Scientific Lab., NM (USA)). Aug 1979. Contract W-7405-ENG-36. 16p. Dep. NTIS, PC A02/MF A01.

This report summarizes results of ongoing experiments designed to develop automated flow-analysis assay methods for discerning damage to exfoliated respiratory tract cells in model test animals exposed by inhalation to physical and chemical agents associated with the production of synthetic fuels from oil shale and coal, the specific goal being the determination of atypical changes in exposed alveolar macrophages and epithelial cells. Animals were exposed to oil shale particles (raw and spent), silica, and polystyrene latex spheres via intratracheal instillation. Respiratory tract cells were obtained by lavaging the lungs with normal saline, stained with mithramycin for DNA content, and analyzed using flow cytometric analysis methods. In addition to measuring DNA content, differential and total cell counts were made on all samples analyzed. DNA content frequency distribution histograms and cytology showed definite atypical changes resulting from exposure to shale and silica particulates when compared to the controls. To continue development of fluorescence staining methods for measuring intracellular enzymes in alveolar macrophages, studies were initiated for determining β-glucuronidase using naphthol AS-BI-β-d-glucuronic acid as a fluorogenic substrate. As this new technology becomes adapted to analyzing pulmonary macrophages and epithelial cells, the measurement of physical and biochemical properties as a function of exposure to particulate and gaseous toxic agents related to the production of synthetic fuels will be increased. This analytical approach is designed to assist in the establishment of future guideline for estimating the risks to exposed humans.

409 (LA--8032-MS) AIR SAMPLING AT PARAHO OIL SHALE OPERATIONS. Garcia, L.L.; Schulte, H.F. (Los Alamos Scientific Lab., NM (USA)). Sep 1979. Contract W-7405-ENG-36. 17p. Dep. NTIS, PC A02/MF A01.

This report provides information on worker exposures related to shale oil recovery and processing. Air sampling was limited to mining, crushing, and retorting processes. Major emphasis was placed on the above ground semiworks retort developed by Paraho Development Corporation because of the uniqueness of the process. Air sampling was conducted with direct reading instruments and by gravimetric analysis. Dust, gas, and vapor concentrations potentially hazardous to worker health were noted at most work areas. However, no personal samples were taken to evaluate individual exposures on any workers, therefore, values are indicative only of area concentrations and not personnel exposures. Due to the research nature of this Paraho retorting operation, the concentrations at the various areas would not be indicative of a commercial operation. However, sampling results indicate commercial operations will require control measures to limit worker exposures to acceptable levels. 15 figures, 7 tables.

410 (LA-UR--79-554) CHROMOSOME ABERRATIONS AND LOSS OF SOME CELL FUNCTIONS FOLLOWING IN VITRO EXPOSURE TO RETORTED OIL SHALE. Stroud, A.N. (Los Alamos Scientific Lab., NM (USA)). 1979. Contract W-7405-ENG-36. 18p. (CONF-790334--1). Dep. NTIS, PC A02/MF A01.

From Oil shale symposium; Denver, CO, USA (26 Mar 1979).

An investigation of cellular level effects of processed oil shale from a simulation of modified in situ retorting was undertaken as part of an assessment of the toxicity and mutagenicity of oil shale. Complete assessment of the health hazards associated with physical contact, inhalation, or ingestion of oil shale has not been examined in humans and until it becomes practical to assess these hazards in man, we must rely upon well established in vitro detection procedures in addition to whole animal testing. CHO cells and L-2 rat lung epithelial cell lines were exposed in vitro to processed oil shale particles at different intervals following exposure. Cells were analyzed for chromosome alterations, cell colony forming ability, DNA synthesis, and cell transformation. The results of these studies demonstrate that retorted oil shale, under these experimental conditions, does modify cells in vitro. Chromosome aberrations increased with dose, cell colony forming ability decreased exponentially with dose, and the rate of DNA synthesis was affected, however cell transformation was not demonstrated after 3 months.

411 (LA-UR--79-1014) INHALATION TOXICOLOGY OF OIL SHALE-RELATED MATERIALS. Holland, L.M.; Spall, W.D.; Garcia, L.L. (Los Alamos Scientific Lab., NM (USA)). 1979. Contract W-7405-ENG-26. 17p. (CONF-790447--3). Dep. NTIS, PC A02/MF A01.

From Health implications of the new energy technologies; Park City, UT, USA (4 Apr 1979).

An effort was made to integrate industrial hygiene studies and chemical analyses with inhalation toxicology experiments in order to identify the pulmonary hazards that may arise from an oil shale industry. Results indicate that raw shale dusts cause very little epithelial or fibrotic reaction. Retorted shales elicit inflammatory reaction with varying degrees of fibrosis and epithelial hyperplasia. The shale dusts appear as agglomerations rather than as individual particles, with a peribronchiolar pattern. The chemical availability of total hydrocarbons and polycyclic aromatics varies inversely with particle size.

412 (LA-UR--79-1955) FLOW CYTOMETRIC METHODS FOR ASSAYING DAMAGE TO RESPIRATORY TRACT CELLS. Steinkamp, J.A.; Wilson, J.S. (Los Alamos Scientific Lab., NM (USA)). 1979. Contract W-7405-ENG-36. 12p. (CONF-790334--12). Dep. NTIS, PC A02/MF A01.

From Oil shale symposium; Denver, CO, USA (26 Mar 1979).

This paper summarizes results of experiments designed to develop automated flow-analysis assay methods for discerning damage to

exfoliated respiratory tract cells in model test animals exposed by inhalation to physical and chemical agents associated with the production of synthetic fuels from oil shale, the specific goal being the determination of atypical changes in exposed lung macrophages and epithelial cells. Animals were exposed to oil shale particulates (raw and spent), silica, and ozone, and respiratory tract cells were obtained by lavaging the lungs with normal saline. Cell samples were stained with fluorescent dyes specific for different biochemical parameters and analyzed as they flowed through a chamber intersecting a laser beam(s) of exciting light where sensors measured fluorescence and light scatter (cell size) on a cell-by-cell basis. Cellular parameters proportional to optical signals were displayed as frequency distribution histograms. Cells also were separated according to cytological features and identified. The basic features of the methodology are presented, along with examples of results that illustrate characterization and analysis of normal and exposed respiratory tract cells based on DNA content, total protein, size, and phagocytic activity.

413 (LBL--8827) CONTINUOUS FLOW BIOASSAY TECHNIQUE FOR ASSESSING THE TOXICITY OF OIL-SHALE-RELATED EFFLUENTS: PRELIMINARY RESULTS WITH TWO SPECIES OF CADDISFLY LARVAE. Russell, P.P.; Resh, V.H.; Flynn, T.S. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). Mar 1979. Contract W-7405-ENG-48. 17p. (CONF-790334--5). Dep. NTIS, PC A02/MF A01.

From Oil shale symposium; Denver, CO, USA (26 Mar 1979).

Two experimental runs were performed in which caddisfly larvae were exposed to various dilutions of oil-shale-related wastewaters in a model stream setting. Another run used a synthetic wastewater compounded from ammonium carbonate. In addition, one run tested the effect of the experimental apparatus, with no wastewater load, on the caddisfly larvae. The activity of the larvae was observed in terms of motility, prepupation behavior and timing, and the abandonment of larval cases.

414 (ORNL--5550) FOSSIL ENERGY PROGRAM. QUARTERLY PROGRESS REPORT FOR THE PERIOD ENDING MARCH 31, 1979. McNeese, L.E. (Oak Ridge National Lab., TN (USA)). Jul 1979. Contract W-7405-ENG-26. 257p. Dep. NTIS, PC A12/MF A01.

This quarterly report covers the progress made during the period January 1 through March 31 for the Oak Ridge National Laboratory research and development projects that are carried out in support of the increased utilization of coal and other fossil fuel alternatives to oil and gas as sources of clean energy. These projects are supported by the DOE Divisions of Fossil Fuel Processing, Fossil Fuel Utilization, Fossil Fuel Extraction, Systems Engineering, Basic Energy Sciences, and Health and Environmental Research, and by the EPA Office of Research and Development through interagency agreement with the DOE.

415 (PNL--2850(Pt.5)) PACIFIC NORTHWEST LABORATORY ANNUAL REPORT FOR 1978 TO THE DOE ASSISTANT SECRETARY FOR ENVIRONMENT. PART 5. ENVIRONMENTAL ASSESSMENT, CONTROL, HEALTH AND SAFETY. Bair, W.J. (Battelle Pacific Northwest Labs., Richland, WA (USA)). Feb 1979. Contract EY-76-C-06-1830. 146p. Dep. NTIS, PC A07/MF A01.

The report is in four sections, corresponding to the program elements: technology impacts, environmental control engineering, operational and environmental compliance and human health studies. Each section was abstracted and indexed separately. (JGB)

416 (UCRL--83185) APPLICATION OF A BATTERY OF SHORT-TERM BIOASSAYS FOR TESTING AND GENETIC TOXICITY OF PARAHO SHALE OIL PRODUCTS. Hatch, F.T.; Timourian, H. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 1979. Contract W-7405-ENG-36. 23p. (CONF-7904109--1). Dep. NTIS, PC A02/MF A01.

From EPA/ORNL synfuel meeting; Triangle Park, NC, USA (26 Apr 1979).

The relative mutagenicity and genetic toxicity of crude, hydrotreated, and refined shale oil products from the Paraho surface retort are to be determined and their potential health hazards compared with similar materials derived from petroleum. This will be done by applying a battery of bioassays consisting of a standard microbial test and in vitro and in vivo mammalian systems to obtain a basis for estimating health hazards to humans.

417 CHEMICAL CHARACTERIZATION AND MONITORING STUDIES OF EFFLUENTS FROM EMERGING FOSSIL FUEL PROCESSES. Clark, B.R.; Guerin, M.R. (Oak Ridge National Lab., TN). pp 148-156 of Speciality conference on: toxic substances in the air environment. Pittsburgh, PA; Air Pollution Control Association (1977).

From APCA specialty conference on toxic substances in the air environment; Cambridge, MA, USA (7 Nov 1976).

Approaches to the chemical characterization of aqueous wastes and gas phase fugitive emissions are discussed. Characterization studies are directed toward known hazardous materials or toward chemical class fractions and components deemed likely hazards from bioactivity data obtained in the development of screening methodologies. Analytical techniques include multi-component gas chromatographic profiling with element selective detectors, blind assays using biological activity data, chemical class fractionation for specific compound type characterization and use in bioassay studies, and many conventional method of chemical identification. Specific studies included: characterization of occupational exposure to polynuclear aromatic hydrocarbons (PAH) in fugitive emissions; determination of correlations between PAH content and bioactivity for several materials; analyses of volatile components in headspace gases; analyses of real and synthetic stack gas mixtures; characterization of aqueous by-products from oil shale retorting, coal liquefaction and petroleum refining; and development of bioassay inhalation devices.

MARKETING AND ECONOMICS

418 (DOE/TIC--10019) SHALE OIL: FOCUS GROUP RESULTS. (Market Facts, Inc., Washington, DC (USA)). Aug 1978. Contract EV-78-C-01-6458. 74p. Dep. NTIS, PC A04/MF A01.

The focus group research on oil shale development prepared for the Department of Energy as part of the commercialization program is reported. The research is devoted to evaluation of the potential for commercialization of oil shale, determination of the barriers to development of this resource, and evaluation of actions required by the federal government to promote

commercialization. The group concluded that: the extent of the resource is very large; surface technology is ready for production, though behind schedule, and in situ technology needs further development; the projected cost of shale oil presents a substantial barrier at current oil prices; economic uncertainty is further complicated by the lack of a demonstration plant, delays resulting from the permitting process inconsistencies and changes in Federal regulations; capital is needed for front-end costs but oil shale mining is labor intensive as well; and that capital can help solve the problems of water supply, community development, and regulatory stringency (but not inconsistency).

419 (FE/EES--79/5) BIBLIOGRAPHY OF INVESTMENT COSTS, OPERATING COSTS, AND RELATED ECONOMIC INFORMATION FOR FOSSIL-ENERGY-RELATED INDUSTRIES, JANUARY--DECEMBER 1978. Conley, L.A. (Department of Energy, Morgantown, WV (USA). Morgantown Energy Technology Center). Mar 1979. 42p. Dep. NTIS, PC A03/MF A01.

This report, covering the period January through December 1978, contains 169 abstracts of articles that deal with investment and operating costs, cost estimation methods and theory, developments in technology, and the status of construction projects. The abstracts are of articles from 22 journals. In addition, references are included to selected reports that have been issued through the National Technical Information Service, Springfield, VA. Most of the articles deal with investment and operating costs related to the development of fossil-energy sources. Coal-conversion and coal-mining costs are considered extremely important, since supplies of imported oil are uncertain and because costs of imported oil are rising.

420 (MIT-EL--77-003) RECENT PROPOSALS FOR GOVERNMENT SUPPORT FOR THE COMMERCIALIZATION OF SHALE OIL. A REVIEW AND ANALYSIS. (Massachusetts Inst. of Tech., Cambridge (USA). Energy Lab.). 20 May 1977. Contract EX-76-C-01-2295-006. 58p. Dep. NTIS, PC A04/MF A01.

This report applies the general principles of government-supported commercialization programs to a specific case, that of a proposed program for the commercial demonstration of shale oil production. The report begins with a brief discussion of a proposed commercial demonstration program, followed by a section that sketches the historical, technological, and economic background of shale oil. The commercial implications of this background are discussed. Based on this information, the report then outlines probable industry action in the shale oil field if no government action were taken. Rationales for the proposed program are discussed, both those explicitly offered by the government and others that could have been offered. The program is then evaluated for its effectiveness in dealing with the various problems involved in starting and maintaining a commercially viable shale oil industry. The findings of the analysis are summarized.

421 (ORAU/IEA--79-8(R)) SHALE OIL: U.S. AND WORLD RESOURCES AND PROSPECTS FOR NEAR-TERM COMMERCIALIZATION IN THE UNITED STATES. Marland, G. (Oak Ridge Associated Universities, Inc., TN (USA). Inst. for Energy Analysis). Mar 1979. Contract EY-76-C-05-0033. 59p. Dep. NTIS, PC A04/MF A01.

Although the United States has large resources of shale oil, several decades of development effort have yet to result in a viable industry. Because both the cost of the oil and the environmental impact of its production are not well known and seem to remain perennially at the margin of acceptability, the matter of commercialization has become a political issue. A variety of economic incentives and government programs to encourage commercial development have been proposed - some implemented - and several industrial corporations are proceeding cautiously. Conflicting political, economic, and environmental views, however, continue to preclude a decisive commitment and it does not appear at this time that significant quantities of shale oil will be available in the next decade, or probably even longer.

422 MARKETING PROSPECTUS FOR SHALE OIL. Ogden, G.E.; Ridley, R.D. (Occidental Oil Shale, Inc., Bakersfield, CA). Am. Chem. Soc., Div. Fuel Chem., Prepr.; 23: No. 4, 46-53(1978). (CONF-780902--P2).

From American Chemical Society meeting; Miami, FL, USA (10 Sep 1978).

Viewing the industry sectors in summary, a petrochemical market for shale oil is the most remote. The transportation cost to reach it is high and the upgrading technology for shale oil has not yet been developed. Because it represents one of the more beneficial uses of petroleum, however, it is expected that ultimately a market will develop in this sector. Industrial and utility boiler fuel represent an attractive market for shale oil. Because of the low investment required and a geographically economic location, the first use of shale oil may be for this application in the Great Lakes area. The disadvantages of this market are its susceptibility to environmental and regulatory prohibitions and limited volume demand. The large market for shale oil is expected to be as refinery input. Refined product growth is expected to continue and sufficient plants to absorb sizeable volumes of shale oil exist in economic proximity to the production area. Conversion of shale oil to transportation fuels is consistent with government policy on use of liquid hydrocarbons. The only deterrent to this application is the substantial capital investment for upgrading facilities.

WASTE RESEARCH AND MANAGEMENT

423 (CONF-780903--, pp 116-124) NATURE OF STACK EMISSIONS FROM THE EXPERIMENTAL-SCALE COMBUSTION OF CRUDE SHALE OIL. Clark, B.R. (Oak Ridge National Lab., TN); Higgins, C.E.; Horton, A.D. Jul 1979.

From Symposium on potential health and environmental effects of synthetic fossil fuel technologies; Gatlinburg, TN, USA (25 Sep 1978).

A series of four combustion tests was made with two crude shale oils. Various combustion parameters were measured to assess the combustion behavior by comparison with similar petroleum fuels. Stack emissions were measured with permanent on-line equipment as well as some specially designed apparatus for collecting volatile organic compounds on solid adsorbents for subsequent analysis. The shale oils burned like typical distillate fuel oils with boiler efficiencies comparable to a No. 6 oil. The stack emissions were considerably different in content from those resulting from the combustion of petroleum fuels. Overall hydrocarbon emissions were quite low, but NO/NO/sub x/ emissions were high, reflecting the large nitrogen content of these oils. 3 figures, 7 tables.

424 (CONF-780903--, pp 193-198) FIELD LEVEL CHARACTERIZATION OF SOLID RESIDUES FROM OIL SHALE RETORTING. Skogerboe, R.K.; Berg, W.A.; McWhorter, D.B. (Colorado State Univ., Fort Collins). Jul 1979.

From Symposium on potential health and environmental effects of synthetic fossil fuel technologies; Gatlinburg, TN, USA (25 Sep 1978).

The present report summarizes the results of investigations designed to manage the retorted oil shale (ROS) deposits to minimize subsurface leaching. The chemical characteristics of ROS leachates, the factors which control leaching, the environmental lifetimes of the leachate constituents and their degradation products, and the possible modes of impact on the environment. The chemical and physical properties of ROS will vary considerably with the retorting process used. In this case the ROS used in the lysimeters was produced by a direct gas combustion process. The general water quality of the leachates collected was uniform. A general overview of the leachate composition and the changes in it were deducted from test data. The lower pH observed early in the cycle implies the occurrence of acid production. These constituents showing concentration decreases early in the leaching cycle must be associated with highly soluble and accessible minerals. The present program is moving ahead in characterizing the ways in which environmental factors such as freeze-thaw and wet-dry cycles affect the system. 3 figures, 2 tables.

425 (CONF-790477--1) USE OF OIL SHALE FOR SO_2 EMISSION CONTROL IN ATMOSPHERIC-PRESSURE FLUIDIZED-BED COAL COMBUSTORS. Wilson, W.I.; Snyder, R.B.; Johnson, I. (Argonne National Lab., IL (USA)). 1979. Contract W-31-109-ENG-38. 19p. Dep. NTIS, PC A02/MF A01.

From Annual meeting of national organization for the professional advancement of black chemists and chemical engineers; Houston, TX, USA (18 Apr 1979).

Oil shale--SO_2 reactivity, determined with a thermogravimetric analyzer, was used to estimate the quantity of oil shale required to reduce SO_2 concentration in the effluent gas sufficiently to meet the SO_2 emission standard in atmospheric-pressure fluidized-bed coal combustion (AFBC). It was calculated that the oil shale could reduce the SO_2 concentration in the effluent gas from FBC units below the SO_2 emission limit. In evaluating virgin oil shale and spent oil shale for SO_2 emission control, we compared them with (1) Germany Valley limestone, (2) Greer limestone, and (3) Tymochtee dolomite. The results indicate that, due to the low calcium content of the shale, less dolomite or limestone than oil shale, may be required to meet the SO_2 emission standard. The attrition rate of Green River oil shale was found to be similar to attrition rates of limestones and dolomites.

426 (LBL--8829) RETORT WATER PARTICULATES. Fox, J.P. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). Mar 1979. Contract W-7405-ENG-48. 27p. (CONF-790334--6). Dep. NTIS, PC A03/MF A01.

From Oil shale symposium; Denver, CO, USA (26 Mar 1979).

Particulates were collected from 11 retort waters and their chemical composition and morphology studied using x-ray fluorescence spectrometry, x-ray diffraction and scanning electron microscopy. This work indicates that the particulate fraction of retort water consists of oils and tars, spent shale fines and bacterial cells. Crystals and finely dispersed salts may form during or after vacuum filtration and contribute to the particulate fraction. The crystal phase aragonite was positively identified in one sample. These particulates originate from the suspension of spent shale fines and the formation of an oil--water emulsion during retorting, from the evaporation of an equivalent 1-mm-deep layer of retort water from the filter surface, from CO_2 outgassing during filtration and from bacterial growth in samples maintained at > 4° C. The elements calcium, magnesium, iron, silicon, aluminum, potassium, sodium, nickel, barium, and chromium may be localized in individual particles and are major elements in the particulates. About one percent of the total potassium, arsenic, selenium, bromine, and rubidium in retort water is present in the particulate fraction and significantly greater than one percent of the iron, chromium, mercury and nickel. The elements arsenic,, selenium, rubidium, strontium, mercury, gallium, lead, yttrium, titanium, and manganese are uniformly distributed in the matte material and occur at low levels. The elements mercury, nickel, germanium, arsenic, bromine, iron, and selenium appear to be removed by the bacterial cells. 12 figures, 4 tables.

427 (LBL--8997) WATER QUALITY EFFECTS OF LEACHATES FROM AN IN SITU OIL SHALE INDUSTRY. Fox, J.P. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). Apr 1979. Contract W-7405-ENG-48. 40p. Dep. NTIS, PC A03/MF A01.

This study is an attempt to pull together available information on the leaching of residuals from an in situ oil shale facility. The report evaluates the effect of leachate from abandoned in situ retorts and surface disposal piles of a 100,000 bbl/day, modified in situ facility on the quality of the surface water and groundwater of the Upper Colorado River Basin.

428 (LBL--9002) INTERLABORATORY, MULTIMETHOD STUDY OF AN IN SITU PRODUCED OIL SHALE PROCESS WATER. Farrier, D.S.; Fox, J.P.; Poulson, R.E. (Department of Energy, Laramie, WY (USA). Laramie Energy Research Center; California Univ., Berkeley (USA). Lawrence Berkeley Lab.). Mar 1979. Contract W-7405-ENG-48. 34p. (CONF-790334--7). Dep. NTIS, PC A03/MF A01.

From Oil shale symposium; Denver, CO, USA (26 Mar 1979).

The purpose of the present work was to obtain a careful chemical characterization of an oil-shale process water designated for wide use in environmental research and to determine the suitability of existing analytical methods for this characterization. The study was carried out using an interlaboratory, multimethod approach. Samples from a larger volume, homogeneous reserve of an in situ oil-shale process water were prepared and submitted to 13 laboratories for the measurement of major, minor, and trace elements and standard water quality parameters; a variety of instrumental and chemical methods was used. This paper presents the characterization of that water and discusses analytical problems specific to in situ oil-shale process waters.

429 (LETC/RI--78/7) CHEMICAL CHARACTERIZATION AND ANALYTICAL CONSIDERATIONS FOR AN IN SITU OIL SHALE PROCESS WATER. Fox, J.P.; Farrier, D.S.; Poulson, R.E. (Department of Energy, Laramie, WY (USA). Laramie Energy Technology Center). Nov 1978.

49p. Dep. NTIS, PC A03/MF A01.

Reliable chemical characterizations of oil shale process water have been difficult to obtain due to the lack of standards and limitations of many available analytical methods. These waters are very complex and contain very high or very low levels of many constituents. Chemical interferences are numerous. This paper describes the collection, preparation, stabilization, and chemical analysis of an in situ produced oil shale process water suitable as a reference sample. The sample was produced during the Laramie Energy Technology Center's 1976 Rock Springs Site 9 true in-situ oil shale combustion experiment and carries the designation "Omega-9." The sample was analyzed by 13 separate laboratories using six instrumental techniques and a wide range of wet chemical methods. The results of this survey are presented and discussed. Analytical problems specific to process waters are discussed and recommendations for revised methods and additional research are made. The study demonstrated that many standard analytical methods, such as EPA, USGS or ASTM methods, cannot be used to accurately or precisely determine many water quality parameters in process waters. Poor results were obtained for CN^-, COD, phenols, PO_4^{3-}, solids, HS^-, and others. Instrumental methods, including x-ray fluorescence and neutron activation analysis, produced more accurate and precise results than chemical methods of analysis.

430 (LETC/RI--78/21) POTENTIAL METHODS FOR RESOURCE RECOVERY FROM BLACK WATER OF THE NORTHERN GREEN RIVER BASIN OF WYOMING. Phillips, T.E. (Department of Energy, Laramie, WY (USA). Laramie Energy Technology Center). Dec 1978. 27p. Dep. NTIS, PC A03/MF A01.

Black water is associated with interbedded lean and rich oil shales of the Northern Green River Basin of Wyoming. Oil shale development in the area would require that the black water be removed and processed in some manner. Black water consists primarily of 5 to 8 percent organic acids and 4 to 6 percent sodium carbonate and bicaronate dissolved in water. The solution has a pH of 10. A variety of methods were examined for the separation of organic matter and inorganic salts from black water. Acidifying the black water solution precipitates most of the organic acids. The black water solutes can be concentrated by evaporation of the water or by freezing. Neither liquid-liquid extraction of the black water nor leaching of the black water residue with a variety of solvents appear to be effective methods of separating the organic acids from the salts. Adsorption, coagulation, and ultrafiltration techniques used were inadequate for commercial separation. Reacting the black water under a carbon monoxide atmosphere at elevated temperature and pressure converts the carbonate to bicarbonate and converts 44 percent of the original organic acids to a benzene soluble oil. Due to the economics of the processes and the lack of information on the volume of black water available, removal of the black water from the ground and processing appears unreasonable at this time.

431 (PNL--2596) EVALUATION OF LAND DISPOSAL AND UNDERGROUND INJECTION OF SHALE OIL WASTEWATERS. Mercer, B.W.; Campbell, A.C.; Wakamiya, W. (Battelle Pacific Northwest Labs., Richland, WA (USA)). May 1979. Contract EY-76-C-06-1830. 59p. Dep. NTIS, PC A04/MF A01.

Results indicate that the salinity of retort water, the principal wastewater generated by shale oil recovery operations, will be too high in most cases for irrigation of cover crops needed for effective stabilization by land disposal. Furthermore, large storage lagoons would be required to hold the retort water during the long winters encountered in the oil shale regions of Colorado, Wyoming and Utah. Land disposal cannot be carried out during prolonged periods of freezing weather. Additional problems which may arise with land disposal include air pollution from volatile constituents and groundwater pollution from refractory organics and dissolved salts in the retort water. Pretreatment requirements include the removal of ammonia which is present at toxic concentrations in retort water. Underground injection of retort water may be permitted in regions possessing favorable geological characteristics. It is anticipated that this method would be used as a last resort where effective or resonably priced treatment technology is not available. Regulatory restraints are expected to limit the use of underground injection for disposal of highly polluted shale oil wastewaters. Proving the confinement of injected wastes, a frequently difficult and expensive task, will be required to assure protection of drinking water resources.

432 (TID--28716) ROLE OF SPENT SHALE IN OIL SHALE PROCESSING AND THE MANAGEMENT OF ENVIRONMENTAL RESIDUES. FINAL TECHNICAL REPORT, SEPTEMBER 1976--DECEMBER 1977. Hines, A.L. (Colorado School of Mines, Golden (USA). Dept. of Chemical and Petroleum Refining Engineering). 1 Apr 1978. Contract EX-76-S-04-3780. 107p. Dep. NTIS, PC A06/MF A01.

The program was divided into three major tasks: leaching of spent shale, the development of methods to treat water produced during retorting, and an investigation into the sorptive properties of spent shale. Under Task 1, retorting experiments were carried out on an oil shale with a richness of 19.9 gallons of oil per ton of shale. Chemical and x-ray analyses were carried out on spent shales that had been retorted at temperatures ranging from 300°C to 1,000°C. Retorting times of 2, 5, and 15 hours were also considered. A BET surface area analysis was made on spent shale samples which were retorted at temperatures ranging from 300 to 1,000°C for 2 hours. The maximum surface area of 4.6 m^2/g was found for shale that had been retorted at 700°C. As part of Task II, studies on the hot gas stripping of retort water were considered. In this portion of Task II, a hot gas stripping apparatus was designed and constructed, and CO_2 could be effectively removed from water by hot gas stripping. At a stripping temperature of 200°F and a stripping ratio of 40 SCF/gal, the ammonia concentration was reduced from 11,000 to 3.7 ppM and the bicarbonate concentration was reduced from 47,000 to 220 ppM. The second portion of Task II entailed studying the adsorption of phenol and benzoic acid onto the Rohm and Haas XAD-8 macroreticular resin. Binary adsorption studies of the above materials indicated that phenol was adsorbed onto hydrophobic sites whereas benzoic acid was adsorbed onto hydrophilic sites and onto the hydroxyl group of the phenol. Task III consisted of studying the adsorption of sulfur dioxide on spent shale in packed beds. The adsorption data were modeled by the Langmuir and Freundlich equations.

433 REMOVING SULFUR DIOXIDE FROM GAS STREAMS WITH RETORTED OIL SHALE. Ridley, R.D. (to

Occidental Oil Shale, Inc.). US Patent 4,125,157. 14 Nov 1978. Filed date 12 Jul 1977. 8p.

Sulfur dioxide is removed from a gas stream by passing the gas through retorted oil shale particles containing alkaline earth metal oxides.

434 PURIFYING OIL SHALE RETORT WATER. Yen, T.F.; Findley, J.E. (to Univ. of Southern California). US Patent 4,124,501. 7 Nov 1978. Filed date 4 Aug 1977. 8p.

Anaerobic bacteria, e.g., of the Desulfovibrio family, are added to oil shale retort water producing an increase in cell biomass and reducing sulfate ions present to sulfide. The cell biomass is aggregated into a flocculent mass and removed. The sulfide can be oxidized and recycled to neutralize the retort water. Oxidation of sulfide to sulfate can be accomplished by addition of aerobic bacteria, e.g., of the Thiobacillus family.

435 STUDY EVALUATES TREATMENTS FOR OIL-SHALE RETORT WATER. Harding, B.; Linstedt, K.D.; Poulson, R.E.; Bennett, E.R. (Univ of Colo, Boulder). Ind. Wastes (Chicago); 24: No. 5, 28-33(1978).

The objective of the investigation described was to develop a detailed characterization of the retort water quality, and to evaluate the potential of selected treatment processes for improving the quality of the water to the point that it might be safely discharged or used as a resource in oil shale development. The graphic data presented describe COD breakthrough on activated carbon. 2 refs.

436 UNDERGROUND DISPOSAL OF RETORTED OIL SHALE. Earnest, H.W. (Cleveland-Cliffs Iron Co., Rifle, CO); Rajaram, V.; Kauppila, T.A.; Hill, J.R.M. pp 213-222 of Tenth oil shale symposium proceedings. Reubens, J.B. (ed.). Golden, CO; Colorado School of Mines (1977).

From 10. oil shale symposium; Golden, CO, USA (21 Apr 1977).

Methods for underground disposal of retorted oil shale from a gas combination retorting process include transport and stowing by hydraulic, mechanical, and pneumatic means for a deep mine in the Piceance Creek Basin of northwestern Colorado. Mechanical transport and stowing, using conveyors, was determined to be the most promising system. The various backfilling methods were studied as an integral part of two mining methods: chamber and pillar, and sublevel stoping. Excessive water and energy requirements, poor pillar support characteristics of the backfill, and high costs were the principal reasons for rejecting hydraulic transport and stowing. Excessive energy requirements, severe dust problems, and high costs resulted in the rejection of the pneumatic transport and stowing methods. The surface and underground environmental effects of the various methods were considered in all evaluations. Underground disposal of retorted shale may reduce the amount of material placed on the surface by as much as 85%. Resource recovery may be increased up to 16% when backfilling provides supplementary pillar support and the opportunity to reduce the size of rib pillars. Preliminary operating cost estimates for underground disposal ranged from $0.3101 per ton, for conveyor transport and stowing, to $1.1855 per ton for pneumatic transport and stowing. Operating costs for total surface disposal are estimated to be $0.2438 per ton. 2 figures, 4 tables.

CORPORATE INDEX

In the Corporate Index, report literature is indexed using the name of the organization or institution responsible for issuing the report. Headings are provided for all report literature and for published literature for which a corporate approach is especially desirable, e.g., symposium and conference proceedings.

Each entry under a corporate heading gives the report title and the volume and abstract numbers. Report numbers, if applicable, are given in parentheses at the end of the entry.

DOE Energy Information Data Base: Corporate Author Entries (TID-4585) is used in the standardization of corporate entries. TID-4585 is available for purchase from the National Technical Information Service (NTIS), U. S. Department of Commerce, Springfield, Virginia 22161.

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AUTHOR INDEX

Authors' surnames are indexed in the form appearing in the abstracted publication; given names are reduced to initials. Each author entry gives the publication title and the citation number. Report numbers, if applicable, are given in parentheses at the end of the entry. For publications with multiple authors, an author entry is provided for each. Entries for the second and succeeding authors give references to the first author.

Because of problems involved in the mechanical preparation of this index, all accent marks are omitted. Changes in spelling introduced as a result of accent omission follow standard conventions.

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SUBJECT INDEX

The subject index is based on the use of subject descriptors selected from a controlled thesaurus of terms. Subject descriptors and qualifiers (subheadings) are selected and presented in the following format:

SUBJECT DESCRIPTOR/QUALIFIER
Title, (supplementary information), citation number, (report number)

The title may be supplemented with additional words, or a phrase, if it appears additional information would be helpful. In cases for which the title contains little or no information related to the subject entry, it may be replaced entirely by the supplementary information. A qualifier is not always required, and in such cases the title will follow the unqualified subject descriptor.

The descriptors selected for use as subject terms are generally the names of specific materials, things, or processes. To the extent possible, a qualifier is selected to describe the properties of, or processes applied to, the subject term.

Index entries are selected to indicate the important ideas and concepts presented in the report, rather than words that may appear in the text. Within the available thesaurus terms, the most probable or logical place to look for typical information is selected. "See references" are included to guide users from synonymous terms or phrases to the descriptor selected as a subject heading for the concept. (e.g. Pipeline Quality Gas see HIGH BTU GAS). "See also references" are used to indicate where to find references to subject concepts that are narrower, broader, or related to a particular subject heading. to complete an exhaustive search of a given subject, all such headings should be reviewed.

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A05	8.00	E05	12.50	T05	360.00
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